Earnings Management to Meet Analysts' Forecasts: An Analysis of Information Acquisition and Financial Reporting

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Abbreviations

BSA	Buy-Side Analyst
e.g.	exempli gratia
IASB	International Accounting Standards Board
ibid.	ibidem
i.e.	id est
IFRS	International Financial Accounting Standards
p.	page
SEC	Securities and Exchange Commission
SSA	Sell-Side Analyst

List of Symbols

Symbols for Chapter 3

Greek

$\tilde{\eta}_S/\eta_S$	Noise in the external sender's signal
$\tilde{\eta}_B/\eta_B$	Noise in the internal sender's signal
σ_B^2	Variance of the noise in the internal sender's signal
σ_S^2	Variance of the noise in the external sender's signal
σ_θ^2	Variance of the true state
$\tilde{\theta}/\theta$	True state (of the world)
κ	Scaling factor
λ_B, λ_S	Weights
Σ_β^2	Variance of the bias

Latin

a	Decision maker's action
$\tilde{b}/b$	External sender's bias
$\bar{b}$	Upper bound of the external sender's bias
$C(\cdot)$	Cost function
$C'(\cdot)$	First derivative of the cost function
$C''(\cdot)$	Second derivative of the cost function
$E(\cdot)$	Expected value
F_x	Partial derivative of a function F with respect to x
$N(\mu, \sigma)$	Normal distribution with mean μ and variance σ
P	Market price
p_S	Precision of the external sender's signal

p_B	Precision of the internal sender's signal
q	Probability that the external sender's is biased
$\tilde{s}_S/s_S$	External sender's report
$\tilde{s}_B/s_B$	Internal sender's signal
$\tilde{s}_S^u/s_S^u$	Unbiased external sender's report
$\tilde{s}_S^b/s_S^b$	Biased external sender's report
t	Time
U	Decision maker's utility function
$Var(\cdot)$	Variance

Symbols for Chapter 4

Greek

α, β	Weights
γ	Weight tied to meeting the analyst's earnings forecast
$\varepsilon_a/\tilde{\varepsilon}_a$	Noise in the short-horizon analyst's private signal
$\varepsilon_b/\tilde{\varepsilon}_b$	Noise in the long-horizon analyst's private signal
η	Noise in the firm's accounting earnings
$\tilde{\theta}$	Firm's fundamental earnings with realisation θ
σ_a^2	Variance of the random variable $\tilde{\varepsilon}_a$
σ_b^2	Variance of the random variable $\tilde{\varepsilon}_b$
σ_θ^2	Variance of the random variable $\tilde{\theta}$
ϕ_0	Constant in the manager's optimal earnings report
ϕ_a	Value relevance of the analyst's earnings forecast in the manager's earnings report
ϕ_m	Value relevance of the firm's accounted earnings in the manager's earnings report

Ω_0	Constant in the short-horizon analyst's forecast
Ω_a	Value relevance of the short-horizon analyst's private signal in the manager's earnings forecast
Ψ_0	Constant in the long-horizon analyst's forecast
Ψ_b	Value relevance of the long-horizon analyst's private signal in the manager's earnings forecast

Latin

$\tilde{b}$	Bias with realisation b
c_a	Cost parameter (short-horizon analyst)
c_b	Cost parameter (long-horizon analyst)
F_x	Partial derivative of a function F with respect to x
$N(\mu, \sigma)$	Normal distribution with mean μ and variance σ
p	Sum of p_θ, p_a, and p_m
p_a	Precision of the short-horizon analyst's private signal
p_b	Precision of the long-horizon analyst's private signal
p_θ	Precision of the prior belief of the fundamental earnings
p_m	Precision of the manager's private signal
q	Sum of p_θ and p_a
Q_a	Accounting quality (short-horizon analyst)
Q_b	Accounting quality (long-horizon analyst)
Q_m	Quality of the manager's earnings report
R_a	Analyst's expected utility (short-horizon analyst)
R_b	Analyst's expected utility (long-horizon analyst)
$\tilde{r}_a/r_a$	Analyst's earnings forecast (short-horizon analyst)
$\tilde{r}_b/r_b$	Analyst's earnings forecast (long-horizon analyst)
$\tilde{r}_m/r_m$	Manager's earnings report

$\tilde{s}_a / s_a$	Short-horizon analyst's private signal
$\tilde{s}_b / s_b$	Long-horizon analyst's private signal
$\tilde{s}_m / s_m$	Firm's accounting earnings
t	Time
$U_a(\cdot)$	Short-horizon analyst's utility function
$U_b(\cdot)$	Long-horizon analyst's utility function
$U_m(\cdot)$	Manager's utility function
v	Sum of p_θ, p_b, and p_m
w	Sum of p_θ and p_b

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Abstract

The use of earnings management to produce earnings reports that meet analysts' earnings forecasts is widespread among managers of public firms. This dissertation studies how the managerial incentive to meet the analysts' earnings forecasts affects the analysts' information acquisition and their earnings forecasts. To explore this setting, a three-stage signalling model is proposed that builds on the work of Cheng et al. (2006). The model shows that a rise in a manager's incentive to meet the analyst's forecast reduces the extent to which the analyst acquires costly information on the firm's fundamental earnings. This has a negative impact on the quality of both the analyst's earnings forecast and the manager's reported earnings.

Zusammenfassung

Um die Gewinnprognosen der Analysten zu erfüllen, nehmen Manager von börsennotierten Unternehmen oft Einfluss auf die eigene Berichterstattung über den Unternehmensgewinn. Die vorliegende Arbeit untersucht, wie sich die Absicht eines Managers, die Gewinnprogosen der Analysten zu erfüllen, auf deren Informationsbeschaffung und deren Gewinnprognosen auswirkt. Um diesen Zusammenhang zu untersuchen, wird ein dreistufiges Modell entwickelt, das auf der Arbeit von Cheng et al. (2006) aufbaut. Aus dem Modell geht hervor: Je mehr der Manager beabsichtigt, die Gewinnprognose des Analysten zu erfüllen, umso geringer ist das Ausmaß, in dem sich der Analyst Informationen über die Unternehmensgewinne beschafft. Dies wirkt sich qualitätsmindernd auf die Gewinnprognose des Analysten und den Ergebnisbericht des Unternehmens aus.

1 Introduction

There is ample empirical evidence to support the claim that earnings management is a widespread practice among managers. [1] According to Norman Johnson, the former Commissioner of the U.S. Securities and Exchange Commission (SEC), the main reason for this is the pressure on managers to meet analysts' expectations of earnings.[2] Nevertheless, the role of meeting analysts' expectations remains underexamined in the theoretical literature on earnings management. On these grounds, this dissertation proposes a parsimonious model of earnings management in which a manager has an incentive to meet the expectation of an analyst. This model builds on the work of Cheng et al. (2006). The background against which the model proposed in this dissertation was developed is described in the next section and afterwards, in section 1.2, the objective of this dissertation is outlined.

1.1 Background

From the outset, earnings management refers to the deliberate steps taken by managers to adjust their firm's publicly reported earnings by using the discretion in accounting rules.[3] If, for example, a manager intends to sell shares in the short term, he may attempt drive the stock price up by inflating the earnings report he publishes. While earnings management is legal, its use for the deliberate misrepresentation of firm performance is viewed as unethical.[4] To manage earnings, managers make use of a broad range of different techniques, such as inflating earnings by terminating pension plans, reducing depreciation expenses by overestimating the write-off period, or smoothing income by delaying when transitions are recorded. Compared to other metrics of firm performance (such as cash flows and revenues), academic research on both

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[1] See, for example, McNichols and Wilson (1988); Burgstahler and Dichev (1997); and Nelson et al. (2002).

[2] See Johnson (1999).

[3] See Ning (2009, p. 33).

[4] See, for example, Balakrishnan et al. (2013).

accrual-based and real earnings management usually centres around earnings figures. Unsurprisingly so, because, for outsiders, earnings figures are the preferred measure of firm performance.[5] As a result, earnings figures present an impactful lever for misrepresenting a firm's performance. For this dissertation, the earnings management efforts directed at meeting analysts' expectations expressed in earnings forecasts are particularly relevant. But why do managers attempt to meet analysts' expectations? Prior literature finds several reasons that justify this behaviour related to capital market incentives, career concerns, or reputational effects.[6] For concreteness, a manager may, for example, attempt to meet the analysts' earnings forecasts to ensure that the firm's underlying earnings process is perceived as predictable by the investors which, in turn, can have a positive effect on the firm's bond rating.[7]

Most prior literature on earnings management is focused on public firms because, compared to private firms, financial information on public firms is more readily available. This is due to the fact that public firms have observable equity prices, have mandatory disclosure rules, and are subject to significant analyst coverage.[8] Consequently, in the context of earnings management, private firms have received less attention form academic researchers. However, anecdotal evidence suggests that private firms offer particularly fertile grounds for managing earnings because the lower exposure to public scrutiny means that attempts to manage earnings are less likely to be discovered. Moreover, it is also worthy to note that the desire to meet analysts' forecasts is not limited to the managers of public firms. Private companies with publicly traded debt are also covered by analysts (specifically, debt-analysts) and required to publicly disclose financial information.[9] Needless to say, the motives that drive the private firm's manager to meet the analysts' expectations will differ from the ones of a public firm's manager.[10]

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[5] See Graham et al. (2005).

[6] See, for example, Skinner and Sloan (2002); and Graham et al. (2005).

[7] See Jiang (2008).

[8] See, for example, Gillette (2020); and Givoly et al. (2010).

[9] Examples of private firms that have issued public debt include Bosch, a multinational engineering company; Cargill, a global food corporation; and DZ Bank, a leading bank in Germany.

[10] This will be discussed in more depth under section 2.3.

Against this background, this dissertation proposes a model with two strategic players that frames the communication between an analyst and the manager of a firm. First, the analyst decides on how much costly information to gather on the fundamental earnings of the firm. Next, the analyst publishes an earnings forecast to the public. The manager takes the earnings forecast into account and subsequently reports earnings. The objectives of the manager and the analyst are interrelated. On one hand, the manager's long-term objective is to publish an earnings report that reflects the firm's true fundamental earnings, and his short-term objective is to meet the forecast issued by the analyst. The analyst, on the other hand, can either have a short or long-horizon. If the analyst has a short horizon, his objective is to produce a forecast that lies as close as possible to the manager's earnings report. If, however, he has a long horizon, his objective is to produce a forecast that lies as close as possible to the fundamental earnings of the firm.

1.2 Objective

While earnings management has been studied extensively from a theoretical perspective, the theory to explicitly consider a manager's interest in meeting analysts' expectations is sparse. This dissertation attempts to fill this gap by proposing a model in which the manager's choice of earnings report is governed by two forces: first, his interest in truthfully communicating the fundamental earnings of the firm; and, second, his interest in meeting the forecast of an analyst. The objective of this dissertation is threefold. First, to propose a simple model of earnings management in which a manager has the incentive to meeting the forecast of an analyst. Second, to analyse the factors that govern the extent to which the analyst gathers information on the firm's fundamental earnings. Third, to analyse the determinants of the analyst's forecast quality and manager's reporting quality.

This dissertation is structured as follows. The next chapter locates the present study within the relevant literature. In chapter 3, the model that serves as the basis for the one proposed in this dissertation is outlined. In chapter 4, the model of earnings management is introduced, analysed, and evaluated. Last, in chapter 5, the conclusion is stated.

2 Literature Review

The aim of this literature review is to locate the model proposed in this dissertation (hereafter also referred to as "extended model") within the academic literature, to provide empirical support for its assumptions, and to acknowledge its closest theoretical antecedents. The rest of this section is structured as follows. To begin, section 2.1 relates this dissertation to prior literature on information acquisition and communication. Section 2.2 summarizes the literature on financial reporting and earnings management relevant to this dissertation. Last, section 2.3 considers relevant academic research on analysts' earnings forecasts.

2.1 Information Acquisition and Communication

The communication of information is relevant in many economic settings and has received significant attention in prior academic literature. Prior models routinely assume that there is only one sender of information and that the senders are endowed with information. The extended model does not entirely fit this mould because there are two senders, i.e., an accountant and an analyst, and the extent to which the analyst gathers information is explained endogenously. Against this background, this section aims to locate the extended model within the relevant theory on the acquisition and communication of information.

To begin, the relevant literature on how information is transmitted in two-player settings is considered. Next, the literature on information communication in settings with more than two-players is analysed. Last, the literature that considers both the information acquisition and its communication is reviewed.

Two Player Communication Games

The process of gathering information and its communication are key ingredients of the extended model. Perhaps the earliest theoretical antecedents to consider similar settings are J. Green and

Stokey (1980); and Crawford and Sobel (1982). The model of J. Green and Stokey (1980) assumes a two-player setting in which a sender gathers information and communicates it to a receiver who uses the information to decide on an action. Based on the analysis of equilibrium welfare, their model suggests that an increase in the quality of information does not necessarily improve welfare. The model of Crawford and Sobel (1982), in turn, considers an informed sender who communicates a noisy signal to an uninformed receiver. After receiving the information from the sender, the receiver takes an action that affects both agents. Their model suggests that the informativeness of information communicated by the sender increases in the alignment of the agents' preferences.[11]

The seminal contributions of J. Green and Stokey (1980), and Crawford and Sobel (1982) have led to the growth of a new literature on "cheap talk". The term "cheap talk" refers to communication that is non-binding, i.e., does not limit the set of possible strategies; unverifiable, i.e., the exchange of information cannot be verified reliably; and costless.[12] Some notable contributions to this literature include Farrell (1987), Baliga and Morris (2002), and Aumann and Hart (2003). Farrell (1987) considers the influence of cheap talk in a market entry setting. More specifically, two players can nonbindingly communicate whether they intend to enter the market before making an actual entry decision. Compared to the benchmark setting of no communication provided by Dixit and Shapiro (1984), more coordination is achieved if communication is possible, i.e., it is more likely that exactly one firm enters the market.[13] Baliga and Morris (2002) analyse the influence of cheap talk in a game with strategic complementarities. In the presence of strategic complementarities, a player's best response increases in the other player's best response. Finally, Aumann and Hart (2003) characterise rational behaviour in a two-player communication setting that accounts for the length of communication.

[11] See Crawford and Sobel (1982, p. 1432).

[12] See Pang (2005, pp. 1–2).

[13] See Farrell (1987, p. 35).

Three or More Player Communication Games

A commonality among the models mentioned to this point is that they all consider two-player settings. Since the transmission of information need not be limited to two players, extending the research to richer settings with more players has proven a popular avenue of theoretical research worthy of investigation. Settings with one informed sender and two decision makers are, for example, considered by Farrell and Gibbons (1989), and Newman and Sansing (1993). The model of Farrell and Gibbons (1989) yields insight into how the truthful communication from sender to decision maker is influenced by the presence of a second decision maker. Newman and Sansing (1993), in turn, also model an informed sender with two decision makers; however, contrary to Farrell and Gibbons (1989), the actions of the receivers are not independent from each other.

Settings with two informed senders and one decision maker, on the other hand, are considered by Krishna and Morgan (2001), and Austen-Smith (1993). The model of Krishna and Morgan (2001) suggests that consulting both senders is never beneficial if they are biased in the same direction.[14] If, however, the senders are biased in opposite directions, consulting both is always optimal.[15] Austen-Smith (1993) model information transmission in a legislative context. In contrast to pertinent literature, his model is among few to consider the sequential communication of information. This form of communication is particularly interesting because the strategy of the second mover depends on his private information and on the information revealed by the first mover. By comparing the welfare of sequential communication to simultaneous communication, the results suggest that soliciting information sequentially from two senders is the dominant strategy.

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[14] See Krishna and Morgan (2001, p. 747).

[15] Ibid.

Information Acquisition in Communication Games

In the literature reviewed above, the focus lies on the communication of information, whereas its acquisition plays a subordinate role. However, there are several contributions that, similar to the model proposed in this dissertation, consider both components. Austen-Smith (1994) for example, is an early contribution to the literature that considers how information is acquired in a setting of information communication. In his model, the sender has the choice to acquire costly information, and the receiver faces uncertainty concerning whether the sender is informed or uninformed. The results suggest that if the receiver is sure that the sender is informed, then informative signalling is limited to a narrower range of parameter values.[16]

Less abstract compared to Austen-Smith (1994) is the model of Fischer and Stocken (2010). The latter model examines how the amount of costly private information gathered by a sender depends on the precision of public information and on whether the receiver can observe how much is gathered. Their results show, for example, that if the sender's choice of precision is observable and his credibility is not in doubt, the amount of private information gathered and truthfully communicated falls when the precision of public information rises.[17]

Also relevant is Di Pei (2015), who endogenize the information acquisition decision in a two-player setting of information communication. His model shows that conflicts of interest do not make the sender withhold any information from the receiver.[18] The more recent work of Argenziano et al. (2016), who analyse a setting of strategic information communication with costly information acquisition by the sender, is also relevant to the present study. They find that the decision based on a biased sender's signal may be superior to a decision based on information acquired directly by the receiver.[19]

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[16] See Austen-Smith (1994, p. 955).

[17] See Fischer and Stocken (2010, p. 2002).

[18] See Di Pei (2015, p. 145).

[19] See Argenziano et al. (2016, p. 119).

The setting featured in the proposed model is an extension to the model of Cheng et al. (2006), who also consider an information acquisition and communication setting. Specifically, they frame the communication between a receiver (called fund-manager) and two senders (called buy-side and sell-side analyst). Since their model is particularly relevant for the present study, it is summarised and subject to critical review in chapter 3.

2.2 Earnings Management and Financial Reporting

Since earnings management is widespread in practice, it has become a popular avenue of academic research. The earnings management literature is relevant because, in the extended model, the manager employs earnings management to meet an analyst's earnings forecast. Since the literature on earnings management is voluminous, only the most relevant contributions are acknowledged. For a more complete summary of the literature on earnings management see, for example, Healy and Wahlen (1999), Xu et al. (2007), and Sun and Rath (2010). This section begins with a brief history on the standardisation of financial reporting practices. Afterwards, the relevant theoretical and empirical literature on earnings management is reviewed.

Standardisation of Financial Reporting

Financial statements are a principal method of communicating the firm's economic position from within the firm to the firm's external stakeholders (e.g. providers of debt and equity capital, financial intermediaries, and regulators).[20] To ensure that financial statements portray the economic performance of a firm reliably and credibly, accounting practices have undergone a process of standardisation.[21] In the past, the standardisation was limited to a national level as different nations maintained their own sets of accounting standards.[22] However, the patchwork of disparate accounting standards across countries came into conflict with the growing

[20] See Healy and Wahlen (1999, pp. 365–366).

[21] See Ibid., p. 366.

[22] See IFRS Foundation (2020).

economic interdependence between countries.[23] Firms operating internationally, for example, were expected to apply the corresponding set of local accounting standards to each subsidiary. As another example, investors seeking investment opportunities internationally faced difficulty comparing the economic performance of firms operating under different sets of accounting standards. To address these challenges, a set of internationally recognised accounting standards, otherwise known as the International Financial Accounting Standards (IFRS), was introduced by the International Accounting Standards Board (IASB).

The IASB is composed of independent experts appointed by the trustees of the IFRS Foundation. By 2018, 144 jurisdictions adopted the IFRS for all or most financial institutions and listed companies, and the efforts tied to encouraging its widespread adoption are ongoing.[24] According to the IFRS Foundation (2020), the global adoption of IFRS aims to

- enhance quality and comparability of financial information across companies on a national and international level;
- reduce the gap in information between firms and their stakeholders; and
- improve the economic efficiency in evaluating opportunities and risks.

The contribution of the IFRS towards meeting these aims is frequently studied by empirical researchers. The majority of studies find that the adoption of the IFRS has been beneficial from an economic perspective. Barth et al. (2008) find empirical support for improved accounting quality; Ashbaugh and Pincus (2001) document higher analyst forecast accuracy; Kim and Shi (2012) find that IFRS adoption has improved the extent to which firm-specific information is incorporated into stock prices; and Covrig et al. (2007) find that adopters of IFRS receive higher levels of foreign investment.

[23] See IFRS Foundation (2020).

[24] See IFRS Foundation (2018, p. 2).

Earnings Management

Despite the introduction of accounting standards, financial reports remain imperfect. As a result, self-serving managers can produce financial reports that obscure the true economic performance of their firm to mislead stakeholders. This practice is more commonly referred to as earnings management. Prior literature distinguishes between two types of earnings management: accounting-based and real activities manipulation.[25] The former type refers to the strategic use of accounting techniques (e.g. decreasing estimates of warranty costs) to obscure the true performance of a firm. The latter refers to altering real business transitions (e.g. delaying a desirable investment opportunity).

Providing empirical evidence for the use of earnings management has proven to be a difficult task. Unsurprisingly so, because managers attempt to hide their earnings management efforts. Despite the difficulty, the empirical research documenting the use of earnings management in practice is growing. For example, McNichols and Wilson (1988) provide evidence of earnings management by considering firms' provision for bad debt.[26] Burgstahler and Dichev (1997) find evidence to support the claim that earnings are managed to prevent reporting earnings decreases and losses; Nelson et al. (2002) conduct a questionnaire among 253 auditors who describe 515 specific instances of earnings management attempts; Guidry et al. (1999) find strong evidence for earnings management in multinational firms tied to managers' compensation agreements. The afore mentioned studies constitute only a small part of the broad literature that provides evidence for earnings management. In view of the model presented in this dissertation, the literature documenting that earnings management occurs in relation to a manager's desire to meet analysts' forecasts is most relevant. This branch of literature is discussed in more detail in the next section.

[25] See, for example, Ewert and Wagenhofer (2005, p. 1102).

[26] Bad debt provisions are reserves against uncollectible debts that will need to be written off.

The growing body of empirical literature has fuelled theoretical research on earnings management. Many contributions that study earnings management from a theoretical perspective consider a capital market setting with incomplete private information revelation in equilibrium.[27] For example, Sansing (1992) considers the interdependencies between the forecast published by a firm's manager and the firm's accounting system within a signalling model. As another example, Dye (1988) analyses an intertemporal (overlapping generations) setting where earnings management in one period has an influence on the next. As a final example, Fischer and Verrecchia (2000) study a manager that publishes a potentially biased earnings report in an effort to manipulate his firm's market value. They examine the factors that affect the value relevance of the manager's report in the firm's market price using a comparative static analysis.

Another notable theoretical antecedent of the present study is Stein (1989). His model considers a myopic manager who can boost current earnings by borrowing against earnings that lie in the future. Contrary to the mainstream earnings management literature, the manager considered by Stein (1989) is unable to manipulate the market price of his firm because there is no uncertainty concerning the manager's reporting objective. The present study is similar in spirit because the players' objectives are common knowledge.

Most literature that considers earnings management from a theoretical perspective does not distinguish between the two types of earnings management mentioned earlier, i.e., accounting-based, and real activities manipulation. Instead, accounting systems are frequently modelled in a reduced form that neglects the extent to which each of the afore mentioned types contribute to the earnings management mix. A notable exception to this rule is Ewert and Wagenhofer (2005). In a model that accounts for the two types of earnings management, they find that limiting accounting-based manipulation by introducing tighter accounting standards leads to higher accounting quality but also a higher level of real earnings management. However, as is

[27] See Fischer and Verrecchia (2000, p. 231).

the case with many models on earnings management, the model presented in this dissertation does not distinguish between the two different types of earnings management.

2.3 Analysts' Earnings Forecasts

The extended model includes an analyst whose action (that is, the publication of an earnings forecast) is determined endogenously to the extent that it is the result of a maximisation problem. Since the analyst constitutes an important component of the model, this section reviews relevant literature on the role of financial analysts. To begin, their influence on capital markets is briefly outlined. Afterwards, the significance of meeting analysts' forecasts as an earnings management objective is briefly discussed.

Role of Analysts on Capital Markets

Financial analysts play an important role in the gathering, analysis, and communication of information on capital markets. Prior literature on financial analysts suggests that analysts' forecasts have a significant impact on the firms they cover. For example, Chung and Jo (1996) document that analyst coverage has a positive impact on firm value; Chang et al. (2006) find that analyst following affects firms' equity issuance decisions; and Yu (2008) provide evidence suggesting that higher analyst following reduces earnings management.

Financial analysts are routinely separated into buy- and sell-side analysts. Buy-side analysts are commonly tasked with finding investment opportunities and are employed by investment firms that tend to purchase large portions of securities, such as hedge funds, pension funds, and insurance companies.[28] Sell-side analysts, on the other hand, publish research on a company's securities and are employed at financial institutions that create and market securities, such as brokerage firms; commercial and investment banks; market makers.[29] Contrary to buy-side

[28] See Young (2019).

[29] See Barone (2003).

analysts, the research produced by sell-side analysts is usually made publicly available. There is significant empirical evidence supporting the claim that sell-side analyst research is valuable to individuals who consume the information (see, for example, T. C. Green (2006), Jegadeesh et al. (2004), and Barber et al. (2001)). Figure 1 provides a simplified overview of the flow of information (specified by the arrows) between the buy- and sell-side of financial markets.

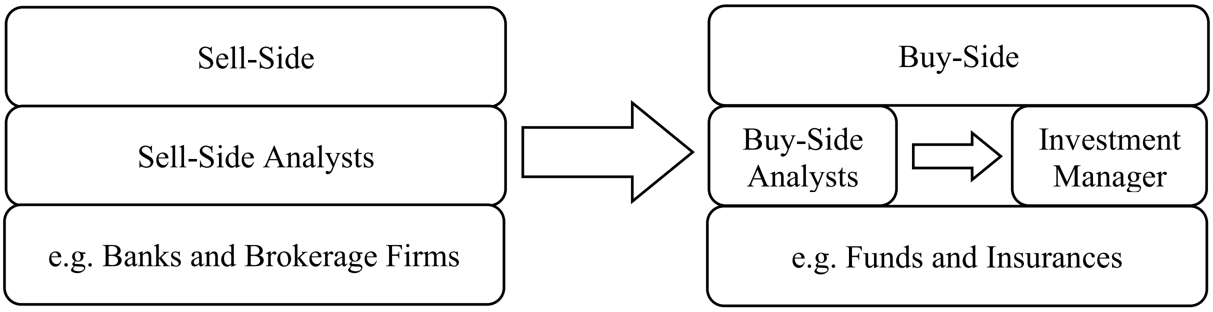

Figure 1: Flow of information between the buy-side and sell-side.[30]

The conflicts of interest tied to the information intermediary role of analysts have become a popular area of theoretical research. Contributions to this stream of research that relate to this dissertation include Morgan and Stocken (2003), Callsen-Bracker (2007), and Trueman (1994). The seminal contribution of Morgan and Stocken (2003) considers a setting where a privately informed analyst releases a potentially biased stock report to an investor. The investor, in turn, makes an investment decision based on the information provided by the analyst. They find, among other things, that the analyst's information is never fully revealing if there is uncertainty surrounding his incentives. Uncertain analyst incentives are also relevant in the model of Callsen-Bracker (2007), who analyses the influence of analyst coverage on the market value of a firm. His primary finding is that the price efficiency increases in the number of analysts covering the firm's stock. Finally, Trueman (1994) shows that analysts tend to exhibit herding behaviour by publishing forecasts that are similar to those published by other analysts.

[30] See Enke and Reimann (2003, p. 3).

Meeting Analysts' Earnings Forecasts

The terms miss, meet, and beat are routinely used to express the relation between a manager's reported earnings and an analyst's earnings forecast. If a manager reports earnings that fall short of, are equal to, or exceed the forecast of an analyst, they are said to miss, meet, or beat the forecast, respectively. Although analysts are involved in forecasting a wide variety of firm metrics (e.g. dividends, cash flows, and revenues), most attention is devoted to analysts' earnings forecasts.[31] Perhaps the most important reason for this is that earnings explain security returns overwhelmingly well in the long term.[32]

Managers attribute a significant amount of importance to reporting earnings that meet analysts' forecast. It is therefore unsurprising that regulators suspect the use of earnings management in that context. Norman Johnson (1999), former Commissioner of the U.S. Securities and Exchange Commission (SEC), states: "Perhaps the single most important cause [of earnings management] is the pressure imposed on management to meet analysts' earnings projections". Studies that compare the propensity of earnings management between public and private firms remain in disagreement. While Burgstahler et al. (2006) find that earnings management is more prevalent among managers of private firms, Beatty et al. (2002) come to the opposite conclusion.[33] Degeorge et al. (1999) show that the use of earnings management as a response to meeting analysts' forecasts is widespread among managers because there are strikingly few reports that either just fall short of the consensus analyst forecast or exceed it by a large margin.[34] This observation is supported by Burgstahler and Eames (2006), who show that earnings management is used to either meet or narrowly beat analysts' forecasts; and Payne and

[31] See Graham et al. (2005).

[32] See Easton et al. (1992).

[33] See Givoly et al. (2010, p. 196).

[34] See Degeorge et al. (1999, pp. 20–21)

Robb (2000), who provide evidence to support the prediction that managers engage in earnings management to minimize both positive and negative earnings surprises.[35]

A question that remains to be addressed is why managers are so concerned with meeting analysts' forecasts. Managers are concerned with meeting analysts' forecasts because outsiders who evaluate the firm's performance find it to be important.[36] These outsiders often exhibit a "threshold mentality" that derives from the pervasive human tendency to attribute importance to certain focal points.[37] With regard to analysts' earnings forecasts, meeting them is perceived as the norm which, in turn, makes the norm a focal point.[38] Since debt and equity markets provide fertile grounds for outsiders to express their opinions, the pressure on managers to meet analysts' forecasts is more pronounced among firms with publicly listed equity or debt compared to firms with private debt and private equity.

Prior research identifies several rewards for achieving to meet the analysts' forecast. Kasznik and McNichols (2002), for example, find evidence that the market rewards public firms which meet the analysts' expectations by assigning a higher value to them. Jiang (2008), as well as Crabtree and Maher (2005) find empirical evidence to support the claim that higher bond (debt) ratings are granted to firm's that meet analysts' expectations; Rickling et al. (2013) document that meeting analyst expectations lowers firms' audit fees; and Graham et al. (2005) provides survey results that suggest reputational benefits arise for managers who meet analysts' earnings forecasts. Besides these rewards, other reasons that justify the motive of meeting analysts' earnings forecasts include the following. Earnings in excess of the analysts' forecasts could be managed down to store earnings for future periods; meeting analysts' forecasts helps build a reputation for predictable earnings; earnings above the analysts' forecasts could be managed

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[35] The earnings surprise is defined as the difference between a manager's reported earnings and the consensus forecast.

[36] See Degeorge et al. (1999, p. 6).

[37] Ibid.

[38] Ibid.

down to reduce the risk of inflating analysts' expectations that make it more difficult to meet future forecasts.[39]

While the empirical research on the topic of meeting analysts' earnings forecasts is voluminous, it has only been researched peripherally from a theoretical perspective. The extended model aims to fill this gap and build an understanding of the implications tied to meeting analysts' forecasts. More specifically, the extended model studies the implications of managing earnings to meet an analyst's forecast on the information acquisition decision of an analyst, the quality of his earnings forecast, and the quality of the manager's earnings report. On this basis, a theoretical model is developed in which meeting the forecast of a (representative) analyst plays a role. This model is introduced in the next chapter.

[39] See Payne and Robb (2000, pp. 373–375).

3 A Model of Information Acquisition and Communication – Cheng et al. (2006)

The seminal work of Cheng et al. (2006) investigates how institutional investors use information from analysts when making an investment decision. For this purpose, they propose a simple two-stage signalling model that frames the behaviour of a decision maker (or, receiver), called fund manager, who receives information from two senders (of information), called buy-side analyst and sell-side analyst. While the buy-side analyst gathers information and communicates it truthfully to the fund manager, the sell-side analyst communicates potentially biased information. Upon receiving the information, the fund manager decides on an action. Based on this model, theoretical predictions concerning how the fund manager weighs information from the buy-side and sell-side analyst are derived.

The structure of Cheng et al.'s (2006) model is similar in spirit to the communication games discussed in section 2.1 and it serves as the foundation for the model of earnings management proposed in chapter 4. To establish a basic understanding of the components that underpin the extended model, this chapter describes the work of Cheng et al. (2006) and discusses its findings and assumptions. The remainder of this section is structured as follows. To begin, section 3.1 describes the setup of the model proposed by Cheng et al. (2006). Section 3.2 derives the unique optimum solution of the model. Next, section 3.3 considers the comparative statics of the equilibrium solution. Finally, section 3.4 discusses the assumptions and findings of the model in preparation for the extension in chapter 4.

3.1 Setup

This section describes the setup of Cheng et al.'s (2006) model. The ingredients of the extended model can also be found in other prior studies of information acquisition and communication, such as Fischer and Stocken (2010); or Fischer and Verrecchia (2000). However, the work of

Cheng et al. (2006) is presented here because it is the closest theoretical antecedent of the extended model. Compared to the original model, the description that follows strips away the economic context because it is less relevant for the present study. Consequently, the fund manager, buy-side analyst, and sell-side analyst are simply referred to as the decision maker, internal sender, and external sender, respectively.

Consider a decision maker who receives information on the true state of the world (hereafter, true state) from an unbiased internal sender and a potentially biased external sender. After receiving the information, he decides on an action $a \in (-\infty,\ \infty)$. The common prior belief about the true state, denoted $\tilde{\theta}$, follows a normal distribution with a mean of zero and precision, i.e., inverse of the variance, of $p_\theta \equiv 1/\sigma_\theta^2$. When p_θ approaches positive infinity, the prior information is perfectly informative about the true state; and, when p_θ approaches zero, the prior is entirely uninformative.[40] Throughout this thesis random variables are denoted with a tilde (~), whereas their realisations are denoted without (e.g. θ is the realisation of the random variable $\tilde{\theta}$). Now, the decision maker's utility function is introduced. If the decision maker's action is a and the realised true state is θ, then his utility is given by

$$U = -\kappa(\theta - a)^2, \tag{3.1}$$

where $\kappa > 0$ is a constant parameter. Thus, the decision maker's utility is decreasing in the realised distance between true state, θ, and his action, a. Parameter κ is given exogenously and scales the decision maker's utility for a given distance between the true state θ and the action a.

To this point, the decision maker's prior and utility function have been introduced. Now, the signal structure of the information provided by the internal and external sender is described alongside the timeline of events. For ease of reference, an overview of the entire timeline is provided in figure 2 on the next page.

[40] See Cheng et al. (2006, p. 55).

$t = 0$	$t = 1$	$t = 2$
θ is drawn from $N(0, \sigma_\theta^2)$, decision maker decides on the precision p_B.	Decision maker observes signals s_B and s_S, and then takes action a.	$\tilde{\theta}$ is realised, and the manager's utility U is determined.

Figure 2: Timeline of Cheng et al.'s (2006) model

At the beginning in $t = 0$, the decision maker decides on the precision of the signal to be produced by the internal sender. By assumption, the internal sender is unbiased and communicates his signal exclusively to the decision maker. His signal is characterised by the sum of the true state and a noise term:

$$\tilde{s}_B = \tilde{\theta} + \tilde{\eta}_B, \tag{3.2}$$

where the noise term $\tilde{\eta}_B$ is normally distributed with mean zero and variance σ_B^2. The precision of the signal is defined as the inverse of its noise, that is, $p_B \equiv 1/\sigma_B^2$, and can be improved at the discretion of the decision maker at a cost of $C(p_B)$. In less formal terms, the decision maker's employee, namely, the internal sender, is responsible for gathering the information about the true state which increases the precision p_B of the signal in equation (3.2).[41] In return for gathering information, the decision maker must pay the internal sender for his service. To guarantee the existence of an interior solution, the cost function is chosen such that $C'(p_B) > 0$ and $C''(p_B) > 0$.[42] In this thesis, a signal designates the entity that is transferred from the sender (internal or external) to the receiver (i.e., the decision maker), and the informativeness of a signal is characterised by its precision. Since a rise in precision p_B (fall in σ_B^2) increases the informativeness of the internal sender's signal, it can be thought of as the outcome of the internal sender gathering more information on the true state.

In the first stage (i.e., $t = 1$), the decision maker observes the realisation s_B of the internal sender's signal in equation (3.2). Apart from that, the decision maker also observes the realisation s_S of the signal provided by the external sender which is given by

$$\tilde{s}_S = \left(\tilde{\theta} + \tilde{\eta}_S\right) + \tilde{\beta}, \tag{3.3}$$

[41] The internal sender is employed by the decision maker, hence the name *internal* sender.

[42] See Cheng et al. (2006, p. 56).

where the noise term $\tilde{\eta}_S$ is normally distributed with mean zero and variance σ_S^2. The bracketed term in equation (3.3) characterises the external sender's private signal and its precision is defined analogously to that of the internal sender's signal, that is, $p_S \equiv 1/\sigma_S^2$. There are two key differences between the signal from the internal sender and the one from the external sender. First, the external sender's private signal precision, p_S, is exogenously given, whereas the internal sender's signal precision, p_B, is determined endogenously. Second, contrary to the internal sender's signal, the signal from the external sender has an additional bias term, $\tilde{\beta}$. The bias $\tilde{\beta}$ is assumed to be distributed as follows:

$$\tilde{\beta} = \begin{cases} b, & \text{with probability} \quad q \\ 0, & \text{with probability} \ 1-q\,, \end{cases} \tag{3.4}$$

where $q \in (0, 1)$. So, if the external sender is biased, he adds a constant b to his private signal; and, if he is not biased, he communicates his private signal truthfully to the decision maker. The bias has an expected value of qb and a variance of $\Sigma_{\beta}^2 \equiv q(1-q)b^2$.[43] It is assumed that b is within the following boundaries:

$$0 < b \leq \bar{b} = (2q(1-q)p_S)^{-\frac{1}{2}}. \tag{3.5}$$

The lower bound ensures that the bias has a positive sign. The upper bound, on the other hand, ensures that an increase in the precision of the external sender's signal leads to a decrease in the precision of the internal sender's signal in the optimum.[44] Note that the upper bound for b is equivalent to the condition $2\Sigma_{\beta}^2 \leq p_S^{-1}$. For simplicity, the random variables $\tilde{\theta}$, $\tilde{\eta}_B$, $\tilde{\eta}_S$ and $\tilde{\beta}$ are assumed mutually independent. After receiving the realised signals s_B and s_S, the decision maker takes an action a.

Finally, in the second stage (i.e., $t = 2$), the true state, θ, is realised. The realised true state is observed by all participants described above, namely, the decision maker, the internal sender, and the external sender. Subsequently, the decision maker's utility given in equation (3.1) is

[43] Variance of the bias: $Var(\tilde{\beta}) = q(b-bq)^2 + (1-q)(0-bq)^2 = q(1-q)b^2$.

[44] To see this, refer to p. 37.

determined: $\widetilde{U} = U$. It is assumed that all aspects of the model are common knowledge, unless otherwise stated.

3.2 Optimum Solution

The components described in the preceding section, i.e., the timeline, decision maker's objective function, and structure of information, characterise the setup of Cheng et al.'s (2006) model. This setup is sufficient for an optimum solution to be determined. Recall that the model has three stages. In $t = 0$, the decision maker decides on the precision of the signal to be produced by the internal sender. Then, in $t = 1$, the decision maker weighs the two signals from the internal sender and the external sender and decides on his action. Last, in $t = 2$, the decision maker's utility is determined. For an optimum, the action and signal precision chosen by the decision maker must maximise his expected utility, net of costs. To determine the optimum solution, the model is solved backwards. First, the decision maker's action is determined for a given pair of signals in $t = 1$. Second, the decision maker's choice of information precision which is to be produced by the internal sender in $t = 0$ is determined.

In $t = 1$, the decision maker chooses the action a that maximises his expected utility conditional on observing the realised signals s_B and s_S from the two senders:

$$\max_{a} E\left(-\kappa\left(\tilde{\theta} - a\right)^2 \middle| s_B, s_S\right). \tag{3.6}$$

Thus, the first order condition for the maximisation problem given above is determined, simplified, and set equal to zero:

$$E\left(\tilde{\theta} \middle| s_B, s_S\right) - a = 0.\text{[45]} \tag{3.7}$$

The first order condition in equation (3.7) is met if the decision maker's action, a, equals the expectation of the true state conditional on the realised signals s_B and s_S, $E\left(\tilde{\theta} \middle| s_B, s_S\right)$. It is easy to see that the second order condition for a maximum is satisfied because it is strictly negative:

[45] See appendix B for a detailed calculation of the first order condition.

$d^2E(\tilde{U}|s_B, s_S)/da^2 = -1 < 0$. Therefore, the decision maker's optimal action is obtained directly from rearranging equation (3.7):

$$a = E(\tilde{\theta}|s_B, s_S) = \lambda_B s_B + \lambda_S(s_S - qb), \tag{3.8}$$

where $\lambda_B \equiv p_B/p_\theta + p_S + p_B$ and $\lambda_S \equiv p_S/p_\theta + p_S + p_B$. For a detailed derivation of $E(\tilde{\theta}|s_B, s_S)$, see appendix C. Equation (3.8) shows that the decision maker accounts for the bias $\tilde{\beta}$ by subtracting the expected bias, qb, from the external sender's signal, s_S. Moreover, the weights λ_B and λ_S depend on the relative precision of the signals s_B and s_S, respectively.

In $t = 0$, the decision maker decides on the amount of information that should be gathered by the internal sender. To make this decision, the decision maker needs to account for the following. A higher degree of information acquisition by the internal sender entitles the decision maker to observe a more precise signal $t = 1$; however, it also leads to a higher cost. In other words, the decision maker must choose the precision, p_B, that maximises his expected utility, net of costs. The expected utility, computed in appendix D, is given by

$$E(\tilde{U}) = E\left(-\kappa(\tilde{\theta} - a)^2\right) = -\kappa\left(\frac{1}{p_\theta + p_S + p_B} + \frac{p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^2}\right) \tag{3.9}$$

and, therefore, the decision maker's choice of precision must solve

$$\max_{p_B} -\kappa\left(\frac{1}{p_\theta + p_S + p_B} + \frac{p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^2}\right) - C(p_B). \tag{3.10}$$

The first order condition of the maximisation problem in (3.10) is given by

$$\kappa\left(\frac{1}{(p_\theta + p_S + p_B)^2} + \frac{2p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^3}\right) - C'(p_B) = 0. \tag{3.11}$$

Equation (3.11) is fulfilled if the expected marginal utility resulting from a marginal increase in the precision p_B is equal to the marginal cost of that increase. Since the first term (i.e., the marginal expected utility) and second term (i.e., the marginal cost) respectively decrease and increase in p_B, there exists a unique p_B that solves the equation. This unique solution constitutes an optimum because the second order condition for a maximum is necessarily satisfied

$$\frac{d^2E(\widetilde{U})}{dp_B^2} = -\kappa\left(\frac{2}{(p_\theta + p_S + p_B)^3} + \frac{6p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^4}\right) - C''(p_B) < 0. \qquad (3.12)$$

Therefore, the unique precision p_B that solves equation (3.11) corresponds to the optimal precision of the internal sender's signal. Although it is possible to compute the solution explicitly, the solution is long and unwieldy. So, the analysis that follows is based on the implicit formulation given in (3.11). Figure 3 below illustrates the decision maker's maximisation problem. In the next section, the comparative statics of the optimal precision are analysed.

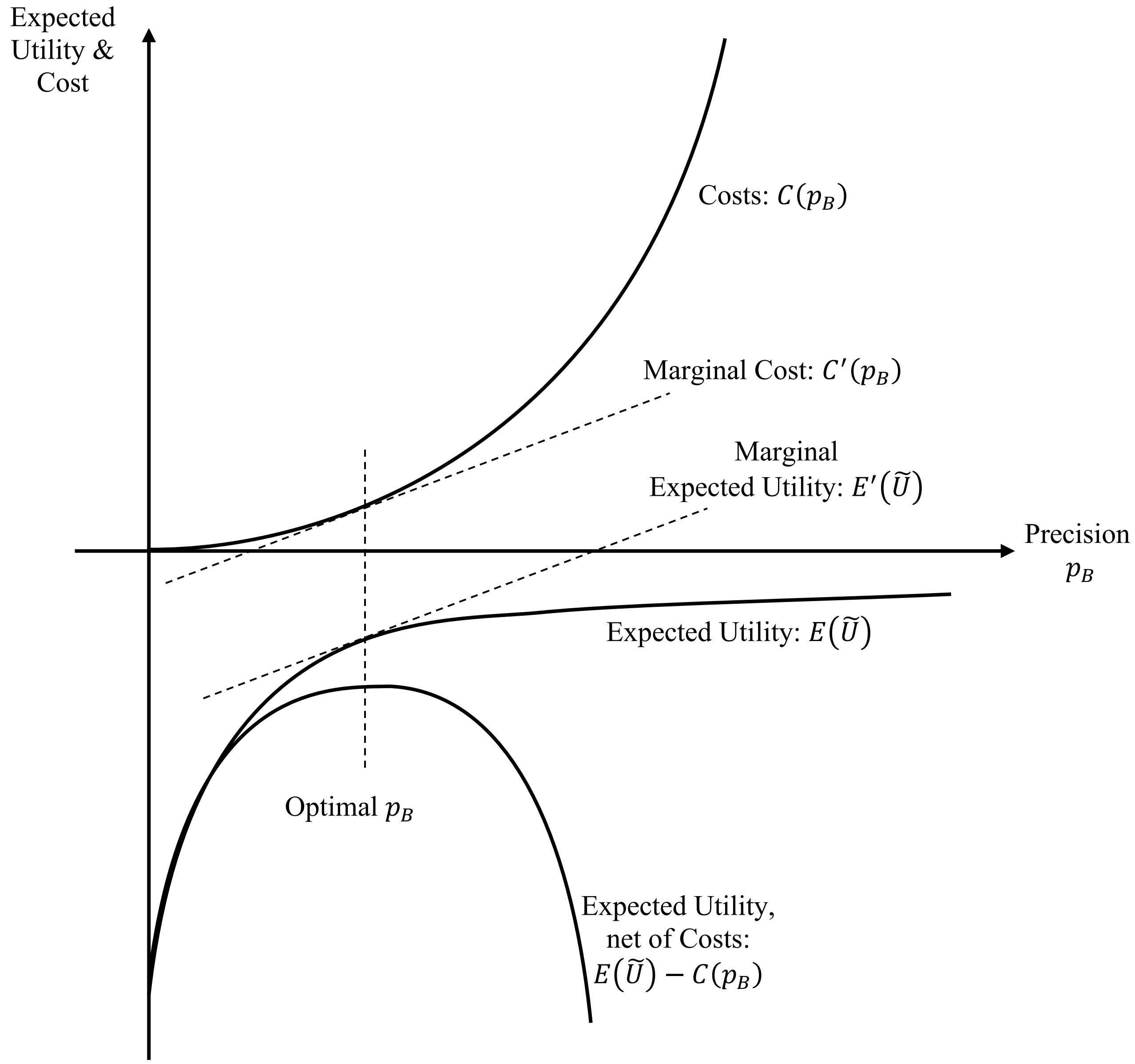

Figure 3: Decision maker's maximisation problem

3.3 Comparative Statics

The preceding section has established that the decision maker's optimal action is given by equation (3.8) and that the optimal precision is given implicitly by equation (3.11). Now, in this section, the influence of changes in the exogenous parameters on the optimal precision are examined by conducting an analysis of the comparative statics. To determine the comparative statics, the method of implicit differentiation is required because the optimal precision characterised by equation (3.11) is given in an implicit form. Note that all comparative statics are derived in detail in appendix E.

Since the method of implicit differentiation will be required frequently throughout this thesis, it is briefly described. As its name suggests, this method is used to determine the derivative of an implicit function. Let $y = f(x)$ be a function of x which is defined implicitly by an equation of the form $F(y, x) = 0$. The method of implicit differentiation states that the derivative of y with respect to x is

$$\frac{dy}{dx} = -\frac{F_x}{F_y}, \tag{3.13}$$

where F_x and F_y are the partial derivatives of the function $F(y, x)$ with respect to y and x, respectively.[46] This method of differentiation is particularly useful when it is unwieldy or not possible to determine an explicit relation of the form $y = f(x)$.

Although it is possible to determine an explicit relation between the optimal precision and the exogenous variables such that $p_B = f(\kappa,\ p_\theta,\ p_S,\ \Sigma_\beta)$, the solution is complex and difficult to analyse. Therefore, the comparative statics of the optimal precision are calculated using the implicit form $F(\ \kappa,\ p_\theta,\ p_S,\ p_B,\ \Sigma_\beta) = 0$ as given in equation (3.11). Against this background, the first comparative static, specifically, the one that relates p_B to κ, will now be determined. To do this, the partial derivative of F with respect to p_B, and the partial derivative of F with

[46] See Callsen-Bracker (2007, pp. 83–84).

respect to κ are required. These are obtained from the implicit function $F(\kappa,\ p_\theta,\ p_S,\ p_B,\ \Sigma_\beta)$ in equation (3.11). So, the partial derivative of F with respect to p_B is given by

$$F_{p_B} = -\kappa\left(\frac{2}{(p_\theta + p_S + p_B)^3} + \frac{6p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^4}\right) - C''(p_B), \tag{3.14}$$

and the partial derivative of F with respect to κ is given by

$$F_\kappa = \frac{1}{(p_\theta + p_S + p_B)^2} + \frac{2p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^3}. \tag{3.15}$$

Given the partial derivatives in (3.14) and (3.15), the derivative of the optimal precision with respect to the parameter κ is

$$\frac{dp_B}{d\kappa} = -\frac{F_\kappa}{F_{p_B}} = \frac{(p_\theta + p_S + p_B)^2 + 2p_S^2\Sigma_\beta^2(p_\theta + p_S + p_B)}{\kappa\left(2(p_\theta + p_S + p_B) + 6p_S^2\Sigma_\beta^2\right) + (p_\theta + p_S + p_B)^4 C''(p_B)} > 0. \tag{3.16}$$

Both the numerator and the denominator in equation (3.16) are positive, so the derivative of the optimal precision, p_B, with respect to the parameter, κ, is greater than zero. Therefore, a marginal increase in the parameter, κ, leads to a marginal increase in the precision, p_B. To understand this result, note that parameter κ characterises the returns to scale of the decision maker's information on the true state. To see this, assume for a moment that the prior is the decision maker's only source of information on the true state. Then his expected utility in equation (3.9) reduces to $E(\tilde{U}) = -\kappa\sigma_\theta^2$, and a unit decrease in the variance of the prior, σ_θ^2, leads to an increase in the expected utility by the amount κ. For $\kappa > 0$, the returns to scale are increasing because a unit increase in the input (i.e., variance) decreases the output (i.e., utility) by more than one unit.[47] With regard to the comparative static result in equation (3.16), this means that the decision maker finds it beneficial to acquire a more precise signal from the internal sender when the returns to scale of information on the true state rise.

[47] Similarly, if $\kappa < 1$, the returns to scale are decreasing; and, if $\kappa = 1$, there are constant returns to scale.

The method used to determine the comparative static result in equation (3.16) can be used as a blueprint for the remaining comparative static results. On that basis, the comparative static that relates the optimal precision, p_B, to the precision of the prior, p_θ, is given by

$$\frac{dp_B}{dp_\theta} = \frac{-\kappa\big(2(p_\theta + p_S + p_B) + 6p_S^2\Sigma_\beta^2\big)}{\kappa\big(2(p_\theta + p_S + p_B) + 6p_S^2\Sigma_\beta^2\big) + (p_\theta + p_S + p_B)^4 C''(p_B)} < 0. \tag{3.17}$$

Since the derivative in equation (3.17) is negative, a marginal increase in the prior precision, p_θ, leads to a marginal reduction in the optimal precision of the internal sender's signal, p_B. This is because an increase in the decision maker's prior precision reduces the expected marginal utility tied to a given level of signal precision from the internal sender while the marginal cost for obtaining this level remains the same. The decision maker responds to this by spending less on the internal sender's service of gathering information. Overall, the prior information becomes more precise relative to the information provided by the senders. Consequently, the decision maker shifts his reliance away from the senders' signals (i.e., s_B and s_S) towards his prior information. It helps to briefly appreciate this from a value relevance perspective. First, consider the value relevance of the internal sender's signal, λ_B, given in equation (3.8). To determine how a change in p_θ influences λ_B, the total derivative of λ_B with respect to p_θ is required:

$$d\lambda_B = \frac{\partial \lambda_B}{\partial p_\theta} dp_\theta + \frac{\partial \lambda_B}{\partial p_B} dp_B + \frac{\partial \lambda_B}{\partial p_S} dp_S. \tag{3.18}$$

By dividing both sides by dp_θ, the derivative of λ_B with respect to p_θ can be determined:

$$\frac{d\lambda_B}{dp_\theta} = \frac{\partial \lambda_B}{\partial p_\theta} + \frac{\partial \lambda_B}{\partial p_B}\frac{dp_B}{dp_\theta},$$

where dp_B/dp_θ is given in equation (3.17).[48] Substituting in the partial derivatives yields:

$$\begin{aligned}\frac{d\lambda_B}{dp_\theta} &= -\frac{p_B}{(p_\theta + p_S + p_B)^2} + \left(\frac{1}{p_\theta + p_S + p_B} - \frac{p_B}{(p_\theta + p_S + p_B)^2}\right)\frac{dp_B}{dp_\theta} \\ &= -\frac{p_B}{(p_\theta + p_S + p_B)^2} + \left(\frac{p_\theta + p_S}{(p_\theta + p_S + p_B)^2}\right)\frac{dp_B}{dp_\theta} < 0,\end{aligned} \tag{3.19}$$

[48] Note that $dp_\theta/dp_\theta = 1$, and $dp_S/dp_\theta = 0$.

Since dp_B/dp_θ has a negative sign, the derivative in equation (3.19) is negative; therefore, a marginal increase in the prior precision reduces the weight on the internal sender's signal. Next, the value relevance of the external sender's signal, λ_S, given in equation (3.8) is considered. Using the same method as above, the derivative of λ_S with respect to p_θ can be determined:

$$\begin{aligned}\frac{d\lambda_S}{dp_\theta} &= \frac{\partial\lambda_S}{\partial p_\theta} + \frac{\partial\lambda_S}{\partial p_B}\frac{dp_B}{dp_\theta} \\ &= -\frac{p_S}{(p_\theta + p_S + p_B)^2}\left(1 + \frac{dp_B}{dp_\theta}\right) < 0\end{aligned} \tag{3.20}$$

where dp_B/dp_θ is given in equation (3.17). Since $1 + \frac{dp_B}{dp_\theta} > 0$, the derivative in equation (3.20) is necessarily negative. Consequently, an increase in the prior precision leads to a reduction in the value relevance of the external sender's signal, λ_S. The last value relevance to be considered is the value relevance of the prior in the decision maker's optimal action, which is given by $\lambda_\theta \equiv 1 - \lambda_B - \lambda_S$. Since the decision maker's prior belief of $\tilde{\theta}$ has an expected value of zero, this component is not visible in the optimal action given in equation (3.8). Nevertheless, given that both λ_B and λ_S are decreasing in p_θ, the value relevance of the prior, λ_θ, is increasing in the prior precision, p_θ.

Now, the influence of a change in the external sender's signal precision, p_S, on the internal sender's optimal signal precision, p_B, is determined. To this aim, the comparative static that relates p_B to p_S is determined:

$$\frac{dp_B}{dp_S} = \frac{-\kappa\left(2(p_\Theta + p_S + p_B) - 2p_S\Sigma_\beta^2(2p_\Theta + 2p_B - p_S)\right)}{\kappa\left(2(p_\Theta + p_S + p_B) + 6p_S^2\Sigma_\beta^2\right) + (p_\Theta + p_S + p_B)^4\, C''(p_B)} < 0 \tag{3.21}$$

At first glance, the sign of the numerator in equation (3.21) appears ambiguous. However, given the assumption made in equation (3.5), that is, $2\Sigma_\beta^2 \leq p_S^{-1}$, the numerator is necessarily negative. To see this, it helps to consider the following:

$$\begin{aligned}&-\kappa\left(2(p_\Theta + p_S + p_B) - 2p_S\Sigma_\beta^2(2p_\Theta + 2p_B - p_S)\right) \\ &\leq -\kappa\left(2(p_\Theta + p_S + p_B) - (2p_\Theta - p_S + 2p_B)\right) = -3\kappa p_S < 0.\end{aligned}$$

Since the numerator is negative and the denominator is positive, the derivative of p_B with respect to p_S is negative. Therefore, a marginal increase in the precision of the external sender's signal leads to a marginal decrease in the precision of the internal sender's signal. This result can be interpreted as follows. For a given precision p_B, an increase in the precision of the external sender's signal, p_S, reduces the decision maker's expected marginal benefit; however, the marginal cost tied to the precision p_B of the signal $\tilde{s}_B$ is unaffected by a change in p_S. Hence, the decision maker weighs a lower benefit for a given precision p_B against an unchanged cost for its acquisition. In an optimum, the decision maker responds to this by reducing the precision p_B for signal $\tilde{s}_B$which he demands from the internal sender.

Finally, the comparative static of the internal sender's optimal precision, p_B, with respect to the variance of the external sender's bias, Σ_β^2, remains to be considered. The comparative static that relates p_B to Σ_β^2 is

$$\frac{\partial p_B}{\partial \Sigma_\beta^2} = \frac{2p_S^2\kappa(p_\theta + p_S + p_B)}{\kappa\left(2(p_\theta + p_S + p_B) + 6p_S^2\Sigma_\beta^2\right) + (p_\theta + p_S + p_B)^4\, C''(p_B)} > 0. \tag{3.22}$$

Both the numerator and denominator of equation (3.22) are positive; therefore, a marginal increase in the variance of the bias, Σ_β^2, leads to a marginal increase in the precision of the internal sender's signal, p_B. This result can be interpreted through the lens of the decision maker's expected marginal utility. An increase in the variance Σ_β^2 reduces the quality of the external sender's signal which, in turn, leads to a rise in the expected marginal utility tied to a given precision of the internal sender's signal, p_B. So, in an optimum, the decision maker demands a more precise signal from the internal sender to compensate for the lower signal quality (resulting from a higher Σ_β^2) provided by the external sender. It is noteworthy, that two values affect the variance $\Sigma_\beta^2 \equiv q(1-q)b^2$ of the external sender's signal, specifically, parameter b and probability q. To evaluate the influence of b and q on p_B, it helps to begin by considering their influence on Σ_β^2. Consider first the influence of b on Σ_β^2 for a constant q. For $q \in (0,1)$, the decision maker does not perfectly back out the bias from the external sender's signal; therefore, the variance of the bias, Σ_β^2, increases in b.[49] Now, consider the influence of q on Σ_β^2 for a constant b. When the uncertainty tied to the external sender's type (i.e., biased or unbiased) is reduced, the variance Σ_β^2 decreases.[50] So, on this basis, the internal sender's signal precision, p_B, increases when the parameter b increases, or when the uncertainty concerning the external sender's type increases.

3.4 Discussion

In the previous sections, Cheng et al.'s (2006) model was outlined. Using this model, they frame how a fund manager (the decision maker) uses the information produced by a buy-side analyst (internal sender) and a potentially biased sell-side analyst (external sender). Furthermore, they derive predictions on how a fund manager weighs the information provided by buy-side and sell-side analysts by conducting a comparative static analysis. Moreover, they test the model predictions against data on U.S. equity funds from Thomson Financial/Nelson Information's Directory of Fund Managers.[51] In this section, the model's assumptions and results are briefly discussed.

Model Setting

Although, as mentioned earlier, the economic context within which the model is originally interpreted is less relevant for the present study, it is worthy to take it into consideration briefly. Originally, in Cheng et al. (2006), the decision maker, internal sender, and external sender are interpreted as a fund manager, a buy-side analyst, and sell-side analyst, respectively. Moreover, the components of the utility function, $U = -\kappa(\theta - a)^2$, are interpreted as follows: κ is a scale parameter; a as an action on a stock, such as a position in buying or selling; and θ is interpreted

[49] However, if $q \in 0{,}1$, the decision maker knows perfectly whether the external sender is biased or unbiased.

[50] A reduction in uncertainty concerning the external sender's type is understood as the shift from $q = 1/2$ to either $q = 0$ or $q = 1$.

[51] See Cheng et al. (2006, p. 60).

variably as either the true state of a stock, or the true state of the world. This economic interpretation chosen by the authors leaves two questions unanswered: What exactly is the true state of a stock? If the true state and action are respectively measured in monetary units and units of shares, then how can the difference $(\theta - a)$ be interpreted?

Visibly, the interpretation of the utility function and economic context chosen by the authors is incomplete. To fill this gap, the utility function could be reinterpreted. The fund manager could, for example, be thought to publish a tender offer price to the shareholders of a public firm he intends to acquire. Then θ and a could respectively be read as the true value of the target firm's shares and the tender offer price announced by the fund manager. With this interpretation, the concave utility structure of U would still be applicable: If the tender offer price communicated by the manager exceeds the true state, he pays too much for the stake in the target firm; likewise, if the tender offer price is below the true value, too few shareholders may tender into the offer and the manager could fail to acquire a controlling stake.

Results of Cheng et al. (2006)

The work of Cheng et al. (2006) investigates how a fund manager weighs the information provided by a buy-side analyst (BSA) and a sell-side analyst (SSA) from both a theoretical and an empirical perspective. The comparative static analysis of the model provides the basis for the hypotheses of the empirical study.[52] The comparative statics suggest that the optimum weight on the buy-side analyst's research increases when the uncertainty of his private signal decreases, when the uncertainty of the sell-side analyst's signal increases, when the bias of the sell-side analyst increases, or when the uncertainty concerning the bias of the sell-side analyst increases.[53] The empirical evidence presented by Cheng et al. (2006) provides strong support for these predictions. Table 1 on the next page provides an overview of the model predictions and empirical support.

[52] The comparative statics are given in section 3.3.

[53] See Cheng et al. (2006, p. 51).

Model Predictions		Empirical Support
Factors that increase a fund-manager's weight on BSA research from the model.		Empirical findings that support the predictions derived by the model.
$\downarrow \sigma_B^2$ (or $\uparrow p_B$)	A decrease in uncertainty of the BSA's signal.	A fund's reliance on BSA research tends to be higher if performance-based fees are payed.
$\uparrow \sigma_S^2$ (or $\downarrow p_S$)	An increase in uncertainty of the SSA's signal.	Less SSA coverage on the stocks held by a fund tends to increase a fund's reliance on BSA research.
$\uparrow b$	An increase in the bias of the SSA.	A higher average error in the SSA's earnings forecasts tends to increase a fund's reliance on BSA research.
$\uparrow \Sigma_\beta^2$	An increase in the uncertainty concerning the bias of the SSA.	A higher standard deviation in the SSA's earnings forecasts tends to increase a fund's reliance on BSA research.

Table 1: Summary of Cheng et al.'s (2006) results

The next chapter proposes a model of earnings management that builds on the work of Cheng et al. (2006). Therefore, in the following, the assumptions and limitations of Cheng et al.'s (2006) model are briefly discussed.

Structure of the Fund Manager's (i.e., Decision Maker's) Utility Function

The centrepiece of Cheng et al.'s (2006) model is the quadratic loss utility function $U = -\kappa(\theta - a)^2$ that underpins the decision maker's choice of action. An advantage of this type of utility function is that greater negative and greater positive values of the bracketed term, i.e., $\theta - a$, both incur a higher disutility. As a result, the decision maker is incentivised to choose an action, a, that minimises the distance to the true state, θ. This incentive is amplified by the fact that the disutility increases at an increasing rate in the distance between θ and a.

More specifically, an increase in the error (i.e., distance between θ and a) by a factor of two leads to a rise in penalty (i.e., disutility) by a factor of four. Since the decision maker faces uncertainty concerning the true state, the analysis in the previous sections was centred around maximising the expected utility.[54] In the presence of uncertainty, the use of a standard quadratic loss function unfolds another advantage worthy of note: the utility of the decision maker can be decomposed into a mean and variance term. To see this, consider the decision maker's expected utility

$$E(\tilde{U}) = -\kappa\left(Var(\tilde{\theta} - a) + E^2(\tilde{\theta} - a)\right). \tag{3.23}$$

This feature of the standard quadratic loss function greatly simplifies the analysis. If another non-quadratic utility function would have been used in lieu of the standard quadratic loss, then higher order moments would complicate the analysis.[55]

The Buy-Side Analyst (i.e., Internal Sender) and Sell-Side Analyst (i.e., External Sender)

The analysts play a primary role in the model of Cheng et al. (2006). Therefore, their inclusion within the structure of the model merits attention. While the buy-side analyst is assumed to communicate information truthfully, the sell-side analyst is assumed to be positively biased. Indeed, there is significant empirical evidence to support the claim that sell-side analysts are, on average, positively biased – see, for example, Butler and Lang (1991); Groysberg et al. (2013); and Das et al. (1998). Possible reasons for the positive bias in the recommendations of sell-side analysts include higher trading commissions generated though optimistic forecasts; better job prospects for the analyst tied to positive coverage; and informal agreement for positive coverage between the underwriting institution and equity issuer.[56] Moreover, it is worth noting that there needs to be uncertainty concerning the sell-side analyst's bias for it to have an effect on the fund manager's action.[57] If the fund manager knows the sell-side analyst's

[54] See equation (3.6).

[55] See Kapur (1988, p. 309).

[56] See Malmendier and Shanthikumar (2004, pp. 9–11).

[57] See Cheng et al. (2006, p. 55).

bias with certainty, he could retrieve the sell-side analyst's private signal $(\theta + \eta_S)$ by simply subtracting the bias β from the sell-side analyst's signal s_S.[58] As a result, the bias would not have any influence on the fund manager's action. Unlike sell-side analysts, the research conducted by buy-side analysts is generally withheld from the public. Therefore, the empirical research on buy-side analysts is sparse. The study of Groysberg et al. (2013) is among few to specifically consider buy-side analysts. They find that, compared to sell-side analysts, buy-side analysts publish less optimistic recommendations. This supports the way in which the buy-side and sell-side analysts are captured within the model of Cheng et al. (2006).

Assumptions of the Model of Cheng et al. (2006)

In the model, the communication between a fund manager (decision maker), a buy-side analyst (internal sender), and a sell-side analyst (external sender) is reduced to its essence. As a result, the model is traceable, the calculations are simple, and the results are easy to interpret. However, the use of a simplified setting relies on several assumptions that, if loosened, could have an influence on the fund manager's decision. The model assumes, for example, that there are no agency problems between the buy-side analyst and the fund manager; that the buy-side analyst and sell-side analyst are the fund manager's only available sources of information; that the communication game is played only once; and that the bias of the sell-side analyst is strictly positive. If these assumptions were to be loosened, the model would become more reflective of reality. However, it would also make the model more complex and the analysis of the fund manager's behaviour more cumbersome. Against this background, Cheng et al. (2006) employ a parsimonious model setup for the sake of simplicity. After all, the aim of the model is not to capture the minutia of reality but instead to yield insight into the decision making of a fund manager.

[58] See Cheng et al. (2006, p. 55).

Extensions to the Model of Cheng et al. (2006)

The model of Cheng et al. (2006) can be extended in many directions. Presently, it is assumed that the external sender's signal structure is exogenously given. However, the composition of the signal is likely to be the result of an underlying objective. Therefore, one possible extension would be to include an objective function for the external sender that explains the composition of his signal. Another assumption that warrants attention is that there is only one external sender and one internal sender. For the economic context proposed by Cheng et al. (2006) this is particularly unfitting because, in practice, firms are commonly covered by multiple analysts on both the buy-side and sell-side. On this basis, extending the model to account for multiple internal senders and external senders could also be an extension worthy of analysis. The next chapter proposes a model of earnings management that extends the model of Cheng et al. (2006).

4 A Model of Earnings Management

In this chapter, the model of Cheng et al. (2006) is repurposed and applied to a managerial reporting setting. For this purpose, several adjustments need to be made to the original model. These adjustments will be discussed in the subsequent sections. To establish an understanding for how the original model can be projected onto a managerial reporting setting, it helps to consider the following. The decision maker's objective resulting from equation (3.1) is, in essence, to minimise the expected distance between an unknown true state and his own action. Similarly, a firm's manager may have the objective to publish an earnings report (action) that lies close to the firm's fundamental earnings (unknown true state). This similarity serves as the point of entry to the extended model proposed in this chapter. However, to make the extended model more compelling, the manager is given a second objective, that is, to meet the forecast of an analyst. The extended model has two variants. The first assumes that the forecast horizon of the analyst is short, whereas the second assumes that it is long. In the former case, the (short-horizon) analyst aims to publish a forecast that corresponds to the manager's reported earnings; and, in the latter case, the (long-horizon) analyst aims to publish a forecast that corresponds to the fundamental earnings of the firm. In section 4.1, the short-horizon analyst is considered; and, in section 4.2, the long-horizon analyst is considered.

4.1 Meeting the Forecast of a Short-Horizon Analyst

4.1.1 Setup

Consider a manager who receives information on his firm's fundamental earnings from the firm's accountant and a short-horizon analyst. After receiving the information, the manager publishes an earnings report, $r_m \in (-\infty, \infty)$. The information provided by the short-horizon analyst is captured by $r_a \in (-\infty, \infty)$ and is interpreted as an earnings forecast. For brevity, in section 4.1, the short-horizon analyst will simply be referred to as "the analyst". Both the manager's and the analyst's prior belief is that the fundamental earnings, denoted $\tilde{\theta}$, follow a normal distribution with a mean of zero and a precision, the inverse of the variance, of $p_\theta \equiv 1/\sigma_\theta^2$.

Before the structure of information and timeline of events are introduced, the utility functions of the analyst and the manager are described. Formally, if r_m and r_a respectively denote the realisations of the manager's earnings report and the analyst's forecast, then the analyst's utility is given by the following equation:

$$U_a = -(r_m - r_a)^2. \tag{4.1}$$

Thus, the analyst's utility function is a quadratic loss function in the squared distance between the realisation of the manager's earnings report, r_m, and the forecast issued by the analyst, r_a. It is worthy to note that the analyst decides on the forecast r_a before the manager issues the earnings report r_m. Hence, when deciding on r_a, the analyst has not yet observed the manager's earnings report. This will become clear in the timeline of the model introduced shortly. There are several possible interpretations that justify the disutility tied to the realised distance between r_a and r_m captured by the analyst's utility function, such as worse job prospects, costs to reputation, or lower remuneration for the analyst.

The manager's objective is to issue an earnings report that not only reflects the firm's fundamental earnings but also meets the analyst's forecast. Specifically, if the realisation of the firm's fundamental earnings is θ and the realisation of the analyst's forecast is r_a, then the manager's utility is

$$U_m = -(1-\gamma)(\theta - r_m)^2 - \gamma(r_a - r_m)^2, \tag{4.2}$$

where γ is an exogenously given scale parameter. The manager's utility in equation (4.2) is composed of two terms. First, a quadratic loss in the distance between the realised fundamental earnings θ and the earnings report r_m; and, second, a loss in the squared distance between the realisation of the analyst's report r_a and the manager's earnings report r_m. The weight of the first and second term in the utility function is respectively decreasing and increasing in the scale parameter γ. There are two extreme cases. When $\gamma = 0$, the manager attempts to issue an earnings report that lies as close as possible to the true fundamental earnings. However, when $\gamma = 1$, only the second term in the manager's utility function matters and, therefore, his only incentive is to issue an earnings report that meets the analyst's forecast. To ensure that the equilibrium is unique, the parameter γ must satisfy the following condition: $0 \leq \gamma < 1$.[59]

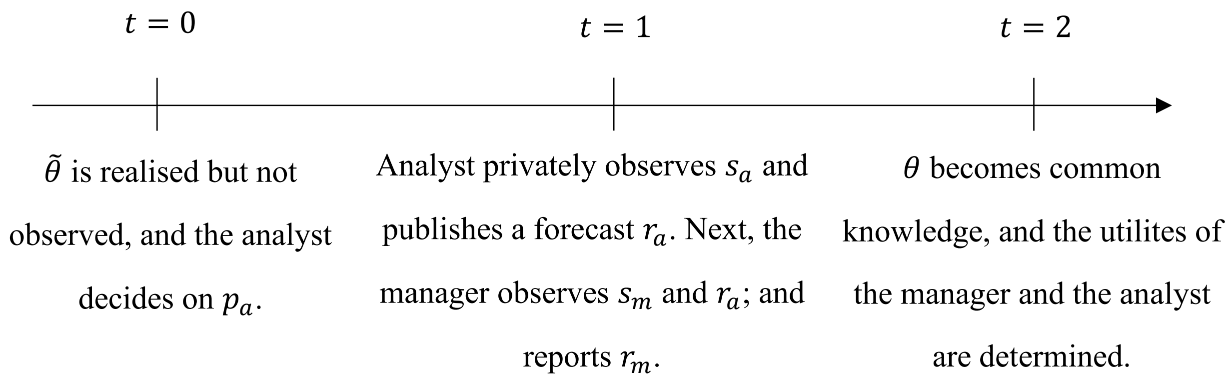

Figure 4: Timeline of events for the model with a short-horizon analyst

The model has three stages and a summary of the timeline is provided in figure 4. In the remainder of this section, the structure of information and sequence of events in the equilibrium model are described in detail.

In $t = 0$, the fundamental earnings of the firm are realised, $\tilde{\theta} = \theta$. However, the realisation of the fundamental earnings remains unknown until the last stage of the model. Furthermore, in $t = 0$, the analyst decides on how much information to gather on the firm's fundamental earnings. By gathering information in $t = 0$, the analyst can improve the precision of his private signal whose realisation he observes in $t = 1$. The signal is private to the extent that it is only

[59] This is discussed in more detail on p. 86

observed by the analyst at the beginning of $t = 1$. Formally, the analyst's signal is composed of the firm's fundamental earnings and a noise term:

$$\tilde{s}_a = \tilde{\theta} + \tilde{\varepsilon}_a, \tag{4.3}$$

where $\tilde{\varepsilon}_a$ is normally distributed, independent of $\tilde{\theta}$, with mean zero and variance σ_a^2.[60] As in the model of Cheng et al. (2006), the precision of a signal is defined as the variance of the signal's error. Accordingly, the precision of the analyst's signal is $p_a \equiv 1/\sigma_a^2$. The analyst's private signal on the firm's fundamental earnings could be obtained from a number of different sources, such as market analysis, customer surveys, and discussions with management. In this model, the precision of the analyst's signal is endogenized. More specifically, the analyst can choose to improve the precision of his private signal, p_a, for a cost of

$$C_a(p_a) = \frac{1}{2} c_a p_a^2, \tag{4.4}$$

where $c_a > 0$ is the analyst's idiosyncratic cost parameter. The cost of gathering information incurred by the analyst is increasing in the precision of the signal at an increasing rate. Since parameter c_a is assumed strictly greater than zero, improving the precision of the signal in equation (4.3) is always costly to the analyst. The feature allowing the analyst to improve the signal precision is similar to the one of the internal sender from chapter 3. The key difference is that, in the model studied here, the cost function takes the specific form given in (4.4). As will become evident later, this generates additional insight because it allows the cost tied to an increase in the precision of the signal $\tilde{s}_a$ to be considered in the comparative static analysis.[61]

In $t = 1$, the analyst observes the realisation of his private signal $\tilde{s}_a = s_a$ and publishes the earnings forecast, r_a. The manager, in turn, receives the forecast published by the analyst, r_a, as well as a private signal s_m on the firm's fundamental earnings. This private signal is interpreted as the accounted earnings and originates from the firm's accountant. The signal

[60] See Fang et al. (2017) or Fischer and Verrecchia (2000) for a similar information structure.

[61] Refer to section 4.1.3 for the comparative static analysis.

provided by the accountant is represented as the sum of the fundamental earnings, $\tilde{\theta}$, and the measurement noise, $\tilde{\eta}$, in the firm's accounting system:

$$\tilde{s}_m = \tilde{\theta} + \tilde{\eta}. \tag{4.5}$$

The measurement noise $\tilde{\eta}$ is normally distributed, independent of $\tilde{\theta}$, with mean zero and variance σ_η^2. The precision of $\tilde{s}_m$ is given by $p_m \equiv 1/\sigma_\eta^2$. It is assumed that the noise terms in the analyst's private signal, $\tilde{\varepsilon}_a$, and the manager's private signal, $\tilde{\eta}$, are mutually independent. If the precision p_m is zero, then the signal is useless because it is extremely noisy; whereas, if the precision p_m approaches $+\infty$, the measurement noise dissipates and signal s_m becomes perfectly informative about the fundamental earnings $\tilde{\theta}$. It is easy to see that the structure of the signals in equations (4.3) and (4.5) is similar to the ones found in the model of Cheng et al. (2006). However, contrary to their model, the present model assumes that the precision of the decision maker's (i.e., firm manager's) private signal is exogenously given. A possible interpretation for this is that the precision of the signal $\tilde{s}_m$ is governed by a certain set of accounting standards beyond the manager's control. As a result, the manager is unable to decide on the precision of his private signal himself.[62]

Finally, in $t = 2$, the fundamental earnings become commonly known $\tilde{\theta} = \theta$. Afterwards, the game ends. At this stage, the utility of the manager and the utility of the analyst are realised. Unless otherwise stated, all aspects of the model are common knowledge. The setup described above is sufficient for an equilibrium to be determined in the next section.

4.1.2 Equilibrium

In this section, the equilibrium solution for the setup described in the preceding section is determined. Consistent with pertinent literature, the analysis that follows is limited to equilibria in linear strategies.[63] Therefore, the forecast published by the analyst is assumed to take the form

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[62] This is discussed in more detail in section 4.3.

[63] See, for example, Fischer and Verrecchia (2000), or Fischer and Stocken (2004).

$$r_a = \Omega_0 + \Omega_a s_a, \tag{4.6}$$

where Ω_0 accommodates for any constant term in the analyst's forecast; and Ω_a is the value relevance of the analyst's private signal, s_a, in the forecast. The calculation of the equilibrium will show that if the analyst's forecast is assumed to be linear as given in equation (4.6), then the earnings report published by the manager of the firm is also linear in the form:

$$r_m = \phi_0 + \phi_a r_a + \phi_m s_m, \tag{4.7}$$

where ϕ_0 accounts for any constant term in the manager's earnings report; ϕ_a captures the value relevance of the analyst's forecast, r_a, in the report; and ϕ_m captures the value relevance of the manager's private signal, s_m, in the report. The model begins with the analyst's decision on how much information to gather on the fundamental earnings of the firm. Subsequently, the analyst publishes the earnings forecast, r_a. The manager observes the forecast and decides on how to weigh his private signal, s_m, and the analyst's forecast, r_a, in the earnings report, r_m. The equilibrium is determined by solving the model backwards. Accordingly, first, the manager's earnings report and the analyst's earnings forecast in $t = 1$ are determined; and, second, the amount of information gathered by the analyst in $t = 0$ is computed. In the following, the computation of the equilibrium solution of the model is described in detail.

To begin, the manager's optimal earnings report in $t = 1$ is determined. The manager's optimal earnings report is derived under the assumption that the analyst's forecast has the form specified in (4.6). Hence, the manager observes the realisations of both his private signal and the analyst's forecast given in (4.5) and (4.6), respectively. Then the manager publishes the earnings report, r_m, that maximises his expected utility conditional on the available information, $E\left(\tilde{U}_m \middle| r_a, s_m\right)$. Formally, the manager's maximisation problem is given by

$$\max_{r_m} E\left(-(1-\gamma)\left(\tilde{\theta} - r_m\right)^2 - \gamma(\tilde{r}_a - r_m)^2 \middle| r_a, s_m\right). \tag{4.8}$$

By expanding the brackets and carrying through the expectation operator, the maximisation problem from equation (4.8) can be rewritten as follows:

$$\max_{r_m} -(1-\gamma)\left(E\left(\tilde{\theta}^2 \middle| r_a, s_m\right) - 2E\left(\tilde{\theta} \middle| r_a, s_m\right) r_m + r_m^2\right) - \gamma(r_a^2 - 2r_a r_m + r_m^2). \tag{4.9}$$

The first order necessary condition for an earnings report, r_m, to constitute a maximum to the problem in (4.9) is obtained by setting the first derivative equal to zero:

$$(1-\gamma)\big(E(\tilde{\theta}|r_a, s_m) - r_m\big) + \gamma(r_a - r_m) = 0. \tag{4.10}$$

Rearranging the condition in equation (4.10) with respect to the manager's earnings report, r_m, yields

$$r_m = (1-\gamma)E(\tilde{\theta}|r_a, s_m) + \gamma r_a. \tag{4.11}$$

To show that the second order sufficient condition for a maximum is satisfied, the second derivative of the manager's expected utility with respect to the manager's earnings report is computed: $d^2E(\tilde{U}_m|r_a, s_m)/dr_m^2 = -1 < 0$. Since the derivative is negative, the second order condition is also satisfied. As a result, the earnings report in (4.11) is a maximum to the optimisation problem stated in (4.8).

Let us briefly consider the structure of the manager's optimal earnings report in equation (4.11). The earnings report is the sum of the manager's expectation of the fundamental earnings and the analyst's forecast weighted by $1-\gamma$ and γ, respectively. So, if the manager has no interest in meeting the analyst's forecast, i.e., $\gamma = 0$, then his earnings report corresponds to his rational expectation of the fundamental earnings, $E(\tilde{\theta}|r_a, s_m)$. However, if the manager's incentive to meet the analyst forecast's increases, i.e., $\gamma \to 1$, then the manager shifts weight away from the conditional expectation of the fundamental earnings, $E(\tilde{\theta}|r_a, s_m)$, towards the analyst's forecast, r_a.

The conditional expectation $E(\tilde{\theta}|r_a, s_m)$ in the manager's earnings report in (4.11) can be calculated in terms of Ω_0, Ω_a, and signal precisions:[64]

$$\begin{aligned} E(\tilde{\theta}|r_a, s_m) &= \frac{p_a(r_a - \Omega_0) + \Omega_a p_m s_m}{\Omega_a(p_\theta + p_a + p_m)} \\ &= \alpha(r_a - \Omega_0) + \beta s_m, \end{aligned} \tag{4.12}$$

where α and β are given by

[64] See appendix F for a detailed derivation of $E(\tilde{\theta}|r_a, s_m)$.

$$\alpha = \frac{p_a}{\Omega_a(p_\theta + p_a + p_m)}, \text{and } \beta = \frac{p_m}{p_\theta + p_a + p_m}. \tag{4.13}$$

Since the expectation in equation (4.12) is conditioned on the analyst's forecast, it depends on Ω_0 and Ω_a that are yet to be determined. After calculating the conditional expectation in equation (4.12), the result is substituted back into the manager's earnings report in equation (4.11):

$$\begin{aligned} r_m &= (1-\gamma)[\alpha(r_a - \Omega_0) + \beta s_m] + \gamma r_a \\ &= (1-\gamma)\alpha r_a - (1-\gamma)\alpha\Omega_0 + (1-\gamma)\beta s_m + \gamma r_a \\ &= -(1-\gamma)\alpha\Omega_0 + \big((1-\gamma)\alpha + \gamma\big) r_a + (1-\gamma)\beta s_m, \end{aligned} \tag{4.14}$$

where α and β are given in (4.13). Substituting the values for α and β into the manager's earnings report yields

$$r_m = \frac{-(1-\gamma)\Omega_0 p_a}{\Omega_a(p_\theta + p_a + p_m)} + \left(\frac{(1-\gamma)p_a}{\Omega_a(p_\theta + p_a + p_m)} + \gamma\right) r_a + \frac{(1-\gamma)p_m}{p_\theta + p_a + p_m} s_m. \tag{4.15}$$

The terms ϕ_0, ϕ_a and ϕ_m can now be determined by comparing equation (4.15) to the assumed linear form of the manager's earnings report stated in equation (4.7). Thus, ϕ_0 is set equal to the constant term in the equation (4.15); and the coefficients ϕ_a and ϕ_m are set equal to the coefficients on r_a and s_m in equation (4.15), respectively. This leads to

$$\begin{aligned} \phi_0 &= -\frac{(1-\gamma)p_a\Omega_0}{\Omega_a(p_\theta + p_a + p_m)}, \\ \phi_a &= \frac{(1-\gamma)p_a}{\Omega_a(p_\theta + p_a + p_m)} + \gamma, \text{and} \\ \phi_m &= \frac{(1-\gamma)p_m}{(p_\theta + p_a + p_m)}. \end{aligned} \tag{4.16}$$

The components of the manager's earnings report determined in (4.16), i.e., ϕ_0, ϕ_a, and ϕ_m, depend on the earnings forecast published by the analyst. This is because the constant term ϕ_0 depends on both Ω_0 and Ω_a; and the coefficient ϕ_a depends on Ω_a. Thus, the next step is to determine the analyst's earnings forecast using the manager's earnings report.

The analyst's forecast is the result of an optimisation problem. Specifically, the forecast published by the analyst maximises his expected utility conditional on the realisation of his private signal, i.e., $E(\tilde{U}_a|s_a)$. Recall that the analyst's utility function is given in equation (4.1). In view of this utility function, it is clear that the analyst attempts to publish a forecast that minimises the expected distance between his earnings forecast, r_a, and the manager's earnings report, r_m, conditional on the realisation of the analyst's private signal, s_a. Formally, the analyst's maximisation problem is given by

$$\max_{r_a} E(-(\tilde{r}_m - r_a)^2 |\, s_a) \tag{4.17}$$

It is worth emphasizing that the analyst observes the manager's earnings report as a random variable, $\tilde{r}_m$, because the analyst issues the forecast before the manager reports earnings. Substituting the manager's earnings report given in equation (4.7) into the analyst's maximisation problem in (4.17) yields

$$\max_{r_a} E(-(\phi_0 + \phi_a r_a + \phi_m \tilde{s}_m - r_a)^2 |\, s_a), \tag{4.18}$$

where ϕ_0, ϕ_m, and ϕ_a are given in (4.16). Expanding the bracket in the maximisation problem above and carrying through the expectation operator leads to

$$\max_{r_a} -E((\phi_0 + \phi_m \tilde{s}_m)^2 |\, s_a) + 2\big(\phi_0 + \phi_m E(\tilde{s}_m |\, s_a)\big)(1 - \phi_a) r_a - (1 - \phi_a)^2 r_a^2. \tag{4.19}$$

The first order necessary condition for the maximisation problem above is obtained by setting the first derivative equal to zero:

$$\big(\phi_0 + \phi_m E(\tilde{s}_m |\, s_a)\big)(1 - \phi_a) - (1 - \phi_a)^2 r_a = 0. \tag{4.20}$$

Rearranging the necessary condition in equation (4.20) with respect to the analyst's earnings forecast, r_a, yields

$$r_a = \frac{\phi_0 + \phi_m E(\tilde{s}_m |\, s_a)}{1 - \phi_a}. \tag{4.21}$$

Now, ϕ_0, ϕ_a, and ϕ_m from (4.16); and explicit form of the conditional expectation $E(\tilde{s}_m|\, s_a)$ are substituted into the analyst's forecast in equation (4.21):[65]

$$\begin{aligned} r_a &= \frac{-\frac{(1-\gamma)p_a\Omega_0}{\Omega_a(p_\theta+p_a+p_m)}+\frac{(1-\gamma)p_m}{(p_\theta+p_a+p_m)}E(\tilde{s}_m|\, s_a)}{1-\left(\frac{(1-\gamma)p_a}{\Omega_a(p_\theta+p_a+p_m)}+\gamma\right)} \\ &= \frac{-p_a\Omega_0+p_m\Omega_a\left(\frac{p_a}{p_\theta+p_a}\right)s_a}{\Omega_a(p_\theta+p_a+p_m)-p_a} \\ &= -\frac{p_a\Omega_0}{\Omega_a(p_\theta+p_a+p_m)-p_a}+\frac{p_a p_m\Omega_a}{(p_\theta+p_a)(\Omega_a(p_\theta+p_a+p_m)-p_a)}s_a. \end{aligned} \tag{4.22}$$

It remains to show, that the analyst forecast in equation (4.22) leads to a maximum. The second order sufficient condition for a maximum is satisfied if the second derivative of the analyst's expected utility with respect to the analyst forecast is smaller than zero. Formally, the following condition must be satisfied:

$$\frac{d^2E(\tilde{U}_a|s_a)}{dr_a^2}=-(1-\phi_a)^2<0. \tag{4.23}$$

Substituting ϕ_a determined in (4.16) into the second order condition above yields

$$-(1-\gamma)^2\left(\frac{\Omega_a(p_\theta+p_a+p_m)-p_a}{\Omega_a(p_\theta+p_a+p_m)}\right)^2<0. \tag{4.24}$$

Condition (4.24) depends on Ω_a which, to this point, has not yet been determined. However, the subsequent analysis will show that $\Omega_a=p_a/(p_\theta+p_a)$.[66] Inserting this result into (4.24) and simplifying yields

$$-(1-\gamma)^2\left(\frac{p_m}{p_\theta+p_a+p_m}\right)^2<0. \tag{4.25}$$

Since $\gamma\in[0,1)$, the condition stated in (4.25) is always fulfilled. Therefore, the analyst forecast stated in equation (4.22) does indeed lead to a maximum.

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[65] Note that $E(\tilde{s}_m|\, s_a)=\frac{p_a}{p_\theta+p_a}s_a$ is obtained by using the formula for the conditional expectation of a multivariate normal distribution in appendix A.

[66] See equation (4.27) on the next page.

Next, Ω_0 and Ω_a need to be determined. For this purpose, the constant term in equation (4.22) is set equal to Ω_0, and the coefficient of the analyst's private signal in equation (4.22) is set equal to Ω_a. Bearing in mind that later, in equation (4.27), it will be shown that $\Omega_a = p_a/(p_\theta + p_a)$, the constant term Ω_0 can be determined:

$$\begin{aligned}\Omega_0 &= \frac{-p_a}{\Omega_a(p_\theta + p_a + p_m) - p_a}\Omega_0 \\ &\Leftrightarrow \Omega_0(\Omega_a(p_\theta + p_a + p_m) - p_a) = -p_a\Omega_0 \\ &\Leftrightarrow \Omega_0\Omega_a(p_\theta + p_a + p_m) = 0 \\ &\Leftrightarrow \Omega_0 = 0.\end{aligned} \tag{4.26}$$

Now, consider the coefficient of the analyst's private signal, Ω_a:

$$\begin{aligned}\Omega_a &= \frac{p_m p_a \Omega_a}{(p_\theta + p_a)(\Omega_a(p_\theta + p_a + p_m) - p_a)} \\ &\Leftrightarrow \Omega_a(p_\theta + p_a + p_m) - p_a = \frac{p_m p_a}{p_\theta + p_a} \\ &\Leftrightarrow \Omega_a = \frac{p_m p_a + p_a(p_\theta + p_a)}{(p_\theta + p_a)(p_\theta + p_a + p_m)} \\ &\Leftrightarrow \Omega_a = \frac{p_a}{p_\theta + p_a}.\end{aligned} \tag{4.27}$$

By simply substituting Ω_0 from (4.26) and Ω_a from (4.27) into equation (4.6), the analyst forecast can be written in terms of the exogenous parameters:

$$r_a = \frac{p_a}{p_\theta + p_a}s_a. \tag{4.28}$$

It can be seen from equation (4.28) that the analyst forecast corresponds to his expectation of the manager's private signal, i.e., $E(\tilde{s}_m|s_a)$; however, this is equivalent to his expectation of fundamental earnings conditional on the analyst's private signal, i.e., $E(\tilde{\theta}|s_a)$. Since there is prior uncertainty surrounding the fundamental earnings, i.e., $p_\theta > 0$, there are two extremes to consider.[67] First, if the analyst's private signal becomes perfectly informative (p_a approaches

[67] Prior uncertainty surrounding the fundamental earnings implies that $p_\theta > 0$.

infinity), then the weight on the signal s_a approaches one. Second, if the analyst's private signal is infinitely noisy ($p_a = 0$), then the weight on the signal s_a approaches zero.

Now, Ω_0 from (4.26) and Ω_a from (4.27) are substituted into the manager's earnings report in (4.15):

$$\begin{aligned} r_m &= \left(\frac{(1-\gamma)(p_\theta + p_a)p_a}{p_a(p_\theta + p_a + p_m)} + \gamma\right) r_a + \frac{(1-\gamma)p_m}{p_\theta + p_a + p_m} s_m \\ &= \left(\frac{p_\theta + p_a + \gamma p_m}{p_\theta + p_a + p_m}\right) r_a + \left(\frac{(1-\gamma)p_m}{p_\theta + p_a + p_m}\right) s_m. \end{aligned} \tag{4.29}$$

Thus, the components ϕ_0, ϕ_a, and ϕ_m of the linear form given in equation (4.7) can be written in terms of the exogenous parameters which yields

$$\begin{aligned} \phi_0 &= 0, \\ \phi_a &= \frac{p_\theta + p_a + \gamma p_m}{p_\theta + p_a + p_m}, \text{and} \\ \phi_m &= \frac{(1-\gamma)p_m}{p_\theta + p_a + p_m}. \end{aligned} \tag{4.30}$$

If the manager has no interest in meeting the analyst's forecast (i.e., $\gamma = 0$), then the weights on r_a and s_m reduce to the Bayesian weights.

In stage $t = 0$, the analyst decides on how much information to gather on the fundamental earnings of the firm. Gathering more information at this stage entitles the analyst to a more precise signal in $t = 1$. To evaluate the information acquisition decision of the analyst, the analyst's expected utility needs to be determined. This is done by substituting the manager's optimal earnings report from (4.29), and the analyst's optimal forecast from equation (4.28) into the analyst's utility function in equation (4.1) and computing the unconditional expectation. This is done explicitly in appendix G and yields:

$$\begin{aligned} E(\tilde{U}_a) &= E(-(\tilde{r}_m - \tilde{r}_a)^2) \\ &= -\frac{(1-\gamma)^2 p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)}. \end{aligned} \tag{4.31}$$

Note that the unconditional expectation is calculated above because, in $t = 0$, the analyst has no other information besides his prior information. Clearly, the analyst's expected utility in

(4.31) depends on the amount of information gathered by the analyst which is characterised by the precision p_a. The analyst's maximisation problem is given by

$$\max_{p_a} -\frac{(1-\gamma)^2 p_m}{(p_\theta+p_a+p_m)(p_\theta+p_a)} - \frac{1}{2}c_a p_a^2. \tag{4.32}$$

The first order condition for the maximisation problem in equation (4.32) is determined by setting the derivative of the analyst's objective function with respect to precision p_a equal to zero:

$$\frac{(1-\gamma)^2((p_\theta+p_a+p_m)^2-(p_\theta+p_a)^2)}{(p_\theta+p_a+p_m)^2(p_\theta+p_a)^2} - c_a p_a = 0. \tag{4.33}$$

If the second order condition is satisfied, the precision p_a that solves the equation above constitutes a maximum. The second derivative of the objective function with respect to p_a is given by

$$-\frac{2(1-\gamma)^2((p_\theta+p_a+p_m)^3-(p_\theta+p_a)^3)}{(p_\theta+p_a+p_m)^3(p_\theta+p_a)^3} - c_a < 0. \tag{4.34}$$

Since this condition is necessarily satisfied, the second order condition for a maximum is fulfilled.[68] As a result, the precision p_a that solves equation (4.33) maximises the analyst's utility, net of costs.

It remains to show that there exists a unique precision p_a that solves equation (4.33). The left side of that equation decreases monotonically in p_a, approaches $-\infty$ as p_a approaches $+\infty$, and is positive for $p_a = 0$. So, there exists a unique positive real p_a that solves equation (4.33). Note that the comparative static analysis in the next section is carried out using the implicit form of p_a in equation (4.33). This concludes the calculation of the equilibrium.

To summarise, in an equilibrium, the extent to which the analyst gathers information in $t = 0$ is characterised implicitly by the unique solution, p_a, to

$$\frac{(1-\gamma)^2((p_\theta+p_a+p_m)^2-(p_\theta+p_a)^2)}{(p_\theta+p_a+p_m)^2(p_\theta+p_a)^2} - c_a p_a = 0. \tag{4.35}$$

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[68] Note that $(p_\theta+p_a+p_m)^2-(p_\theta+p_a)^2 > 0$.

In $t = 1$, the analyst privately observes s_a and publishes the optimal earnings forecast

$$r_a = \frac{p_a}{p_\theta + p_a} s_a; \tag{4.36}$$

afterwards, upon receiving the analyst's forecast, the manager's optimal earnings report is

$$r_m = \left(\frac{p_\theta + p_a + \gamma p_m}{p_\theta + p_a + p_m}\right) r_a + \left(\frac{(1-\gamma)p_m}{p_\theta + p_a + p_m}\right) s_m. \tag{4.37}$$

This equilibrium will be subject to a comparative static analysis in the next section.

4.1.3 Comparative Statics

This section examines the influence of changes in the exogenous parameters on the equilibrium solution by undertaking a comparative static analysis. For this purpose, the method of implicit differentiation outlined in section 3.3 will be required. This section is structured as follows. First, the precision p_a, which characterises the amount of information gathered by the analyst, will be considered. Afterwards, the quality of both the analyst's forecast and the manager's earnings report are analysed. Last, the comparative statics of the analyst's expected utility are considered. It is worthy to note that all the comparative static exercises considered in this section are derived in detail in appendix H. To economise notation, let $p \equiv p_\theta + p_a + p_m$, and $q \equiv p_\theta + p_a$.

The analyst's information on the firm's fundamental earnings stems from his prior information and a private signal. Since both sources of information are imperfect, the analyst faces uncertainty regarding the firm's fundamental earnings. While the informativeness of the prior precision (characterised by p_θ) is exogenously given, the informativeness of the analyst's private signal (characterised by p_a) is determined endogenously. The first determinant of the amount of information gathered by the analyst to be considered is the cost parameter c_a. The comparative static result that relates the amount of information gathered by the analyst, p_a, to the analyst's cost parameter, c_a, is

$$\frac{dp_a}{dc_a} = \frac{-p_a q^3 p^3}{2(1-\gamma)^2(p^3 - q^3) + q^3 p^3 c_a} < 0. \tag{4.38}$$

In this derivative, the numerator is necessarily negative, whereas the denominator is positive because $\gamma \in [0,1)$ and $p^3 - q^3 > 0$.[69] Overall, the sign of the derivative (4.38) is negative which means that, in the equilibrium, a rise in the cost parameter, c_a, reduces the precision p_a. In other words, if gathering information on the firm's fundamental earnings becomes more costly, the analyst responds by gathering less. In the extreme, when the cost approaches positive infinity, the precision p_a approaches its lower bound of zero.

Prior uncertainty concerning the fundamental earnings also affects the amount of information gathered by the analyst. To evaluate the influence of a change in the prior precision, p_θ, on the precision of the analyst's private signal, p_a, the following derivative is required:

$$\frac{dp_a}{dp_\theta} = \frac{-2(1-\gamma)^2(p^3 - q^3)}{2(1-\gamma)^2(p^3 - q^3) + c_a q^3 p^3} < 0. \tag{4.39}$$

The derivative in (4.39) has a negative numerator and a positive denominator, so the sign of the derivative is necessarily negative. This means that an increase in p_θ reduces p_a in an equilibrium. In other words, the analyst's incentive to gather costly private information about the firm's fundamental earnings decreases when the prior uncertainty decreases (i.e., higher p_θ). This result is to be expected because the analyst and the manager place less credence on new information in their posterior expectation of the firm's fundamental earnings if the prior becomes more informative. On average, this decreases the expected distance between the analyst's forecast and the manager's report because they share a common prior. Given that the analyst attempts to minimise this distance, his incentive to gather costly private information on the firm's earnings falls.

Now, the influence of a change in parameter γ on the precision p_a is examined. Recall that the parameter γ scales the incentive to meet the analyst's forecast in the manager's utility function in (4.2). The comparative static that ties the precision of the analyst's private signal to the parameter γ is:

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[69] It is easy to see that $p^3 - q^3 = 3p_a^2 p_m + 3p_a p_m^2 + 6p_\theta p_a p_m + p_m^3 + 3p_m^2 p_\theta + 3p_m p_\theta^2 > 0$.

$$\frac{dp_a}{d\gamma} = \frac{-2(1-\gamma)(p^2-q^2)qp}{2(1-\gamma)^2(p^3-q^3)+c_a q^3 p^3} < 0. \tag{4.40}$$

As in the previous two derivatives, the denominator is necessarily positive. However, the numerator is negative because $p^2 - q^2 > 0$.[70] Overall, the sign of the derivative is negative, so a rise in the parameter γ leads to a decrease in the precision p_a. This is because the manager's incentive to publish an earnings report that reflects the fundamental earnings decreases in γ, whereas his incentive to meet the analyst's forecast increases in γ. This reduces the average distance between the analyst's forecast and the manager's earnings report. Since the analyst knows the manager's objective, he can anticipate the manager's heightened incentive to meet his forecast and, therefore, loses incentive to gather costly private information on the fundamental earnings. Note that, as γ approaches one, the amount of information gathered by the analyst, p_a, approaches its lower bound of zero. This is to be expected because, if the manager's only objective is to meet the analyst's forecast, the analyst's objective to produce a forecast that minimises the expected distance to the manager's report is fulfilled by default. In other words, the manager will blindly set his earnings report equal to his observation of the analyst's forecast.

The degree of uncertainty in the manager's private signal also has an influence on the amount of information gathered by the analyst. The comparative static that relates the analyst's private signal precision to the manager's private signal precision is given by

$$\frac{dp_a}{dp_m} = \frac{2(1-\gamma)^2 q^3}{2(1-\gamma)^2(p^3-q^3)+c_a q^3 p^3} > 0. \tag{4.41}$$

The numerator and the denominator in (4.41) are both positive so the derivative has a positive sign. On this basis, an increase in the precision of the manager's private signal, increases the amount of information gathered by the analyst. If the precision of the manager's private signal increases, it becomes more informative of the firm's fundamental earnings. As a result, the manager places less credence on the analyst's report and more on his private signal. To recoup this lost credence, the analyst pre-emptively gathers more costly private information on the

[70] It is easy to see that $p^2 - q^2 = p_m(2p_\theta + 2p_a + p_m) > 0$.

firm's fundamental earnings. A summary of the comparative static results discussed above is given in table 2 below.

	p_θ	p_m	γ	c_a
p_a	$-$	$+$	$-$	$-$

Table 2: Comparative statics of the short-horizon analyst's private signal precision

The analysis above has outlined the key insights concerning the amount of information acquired by the analyst in an equilibrium. Besides the degree of information acquisition, the quality of both the analyst's forecast and the manager's earnings report are also worthy of analysis. The analyst's forecast quality is considered first. The equilibrium quality of the analyst's forecasts is denoted by Q_a and defined as the negative expected squared distance between the fundamental earnings of the firm, $\tilde{\theta}$, and the analyst's optimal forecast, $\tilde{r}_a$:[71]

$$\begin{aligned} Q_a &= E\left(-\left(\tilde{\theta}-\tilde{r}_a\right)^2\right) = -Var\left(\tilde{\theta}-\tilde{r}_a\right) \\ &= Var\left(\tilde{\theta}-\frac{p_a}{p_\theta+p_a}\left(\tilde{\theta}+\tilde{\varepsilon}_a\right)\right) \\ &= Var\left(\frac{p_\theta}{p_\theta+p_a}\tilde{\theta}+\frac{p_a}{p_\theta+p_a}\tilde{\varepsilon}_a\right) = -\frac{1}{p_\theta+p_a}. \end{aligned} \tag{4.42}$$

With respect to the quality measure introduced above, the quality of the analyst's forecast is said to increase in Q_a because, on average, an increase in Q_a decreases the distance between the fundamental earnings, $\tilde{\theta}$, and the analyst's forecast, $\tilde{r}_a$.

Using the measure in (4.42), the influence of changes in the exogenous parameters on the quality of the analyst's forecast are analysed. Conveniently, the influence of the exogenous parameters p_m, γ, and c_a on the quality Q_a can be determined at first glance. This is because the afore mentioned parameters only have an indirect influence on the quality of the analyst's forecast through the precision p_a. To see this, it helps to briefly consider the influence of

[71] This measure is also used by Callsen-Bracker (2007); and Fischer and Stocken (2004).

parameter p_m on the precision p_a as an example. From (4.41), we know that the precision p_a increases in p_m; and, from (4.42), we know that the quality Q_a increases in the precision p_a. As a result, an increase in p_m leads to an increase in the quality Q_a. The comparative static properties of γ and c_a can be determined analogously, and the results are summarised on the next page in table 3.

The influence of p_θ on Q_a, on the other hand, requires further analysis because there exists a direct and an indirect effect. To evaluate this comparative static, the complete derivative is required:

$$dQ_a = \frac{\partial Q_a}{\partial p_\theta} dp_\theta + \frac{\partial Q_a}{\partial p_a} dp_a. \tag{4.43}$$

To obtain dQ/dp_θ, both sides of the equation above are divided by dp_θ which yields

$$\frac{dQ_a}{dp_\theta} = \frac{\partial Q_a}{\partial p_\theta} + \frac{\partial Q_a}{\partial p_a}\frac{dp_a}{dp_\theta}. \tag{4.44}$$

Solving the right-hand side of equation (4.44) explicitly yields the following result:

$$\frac{dQ_a}{dp_\theta} = \frac{1}{(p_\theta + p_a)^2}\left(\frac{c_a q^3 p^3}{2(1-\gamma)^2(p^3 - q^3) + c_a q^3 p^3}\right) > 0. \tag{4.45}$$

The derivative in (4.45) has a positive sign, so an increase in the precision of the prior increases the quality of the analyst forecast. However, there are two countervailing forces. The direct effect of an increase in the prior precision, p_θ, on the quality of the analyst's forecast is positive, whereas the indirect effect on Q_a through the precision p_a is negative. Nevertheless, the direct effect dominates because

$$\left|\frac{\partial Q_a}{\partial p_\theta}\right| > \left|\frac{\partial Q_a}{\partial p_a}\frac{dp_a}{dp_\theta}\right|. \tag{4.46}$$

As a result, the increase in prior precision always leads to an increase in the quality of the analyst's forecast. The comparative static results that tie the quality of the analyst's forecast to the exogenous parameters is summarized in table 3.

	p_θ	p_m	γ	c_a
Q_a	$+$	$+$	$-$	$-$

Table 3: Comparative statics of the short-horizon analyst's forecast quality

Now, the quality of the manager's report is analysed. The measure of quality for the manager's earnings report is similar to that of the analyst's forecast. More specifically, the equilibrium quality of the manager's earnings report, denoted by Q_m , is defined to be the negative expected squared distance between the fundamental earnings of the firm, $\tilde{\theta}$, and the manager's optimal earnings report, $\tilde{r}_m$.[72] Formally, this quality measure takes the following form:

$$\begin{aligned} Q_m &= E\left(-\left(\tilde{\theta}-\tilde{r}_m\right)^2\right) = -Var\left(\tilde{\theta}-\tilde{r}_m\right) \\ &= -\frac{p_\theta + p_a + \gamma^2 p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)}. \end{aligned} \tag{4.47}$$

It is clear from equation (4.47), that the analyst's cost of gathering information, c_a, only has an indirect influence on quality of the manager's earnings report through p_a. Since a rise in c_a decreases p_a, and a reduction in p_a leads to a fall in Q_m, the quality Q_m falls in c_a. The remaining exogenous parameters have a direct and an indirect influence on the quality and, therefore, require closer analysis. To derive the remaining comparative static properties, the complete derivative of Q_m is required:

$$dQ_m = \frac{\partial Q_m}{\partial p_\theta} dp_\theta + \frac{\partial Q_m}{\partial p_a} dp_a + \frac{\partial Q_m}{\partial p_m} dp_m + \frac{\partial Q_m}{\partial \gamma} d\gamma. \tag{4.48}$$

To begin, the comparative static of Q_m with respect to γ is analysed. Accordingly, both sides of equation (4.48) are divided by $d\gamma$ which yields

$$\frac{dQ_m}{d\gamma} = \frac{\partial Q_m}{\partial p_a}\frac{dp_a}{d\gamma} + \frac{\partial Q_m}{\partial \gamma}. \tag{4.49}$$

Solving this derivative explicitly and simplifying leads to

[72] Note that $E\left(\left(\tilde{\theta}-\tilde{r}_m\right)^2\right)$ is calculated explicitly in appendix I as part of the manager's expected utility. By placing a minus before this term, Q_m is obtained.

$$\frac{dQ_m}{d\gamma} = -\frac{2(1-\gamma)(p^2-q^2)\big(q^2+\gamma^2(p^2-q^2)\big)}{(2(1-\gamma)^2(p^3-q^3)+c_a q^3 p^3)qp} - \frac{2\gamma(p-q)}{qp} < 0. \quad (4.50)$$

Since the derivative is negative, the quality of the manager's earnings report Q_m is decreasing in the parameter γ. The direct effect can be characterised as follows. When $\gamma = 0$, the manager's earnings report corresponds to his best prediction of the fundamental earnings; therefore, the weighting scheme on his private information and the analyst's forecast is Bayesian. When γ approaches 1, the manager's incentive to publish a report that meets the analyst's forecast heightens which leads to a disproportionally high weight on the analyst's report lowering the quality of the earnings report. The indirect effect, in turn, also reduces the quality and it results from the analyst's reduced incentive to gather costly private information as γ rises.

Now, the comparative static that ties Q_m to the prior precision p_θ is considered:

$$\frac{dQ_m}{dp_\theta} = \frac{\partial Q_m}{\partial p_\theta} + \frac{\partial Q_m}{\partial p_a}\frac{dp_a}{dp_\theta} = \frac{\big(q^2+\gamma^2(p^2-q^2)\big)c_a qp}{2(1-\gamma)^2(p^3-q^3)+c_a q^3 p^3} > 0. \quad (4.51)$$

The influence of an increase in the prior precision on Q_m seems ambiguous at first sight because the indirect effect $\left(\frac{\partial Q_m}{\partial p_a}\frac{dp_a}{\partial p_\theta} < 0\right)$ and the direct effect $\left(\frac{\partial Q_m}{\partial p_\theta} > 0\right)$ have opposing signs. The indirect effect emerges because a rise in the prior reduces the amount of information gathered by the analyst, lowering the informativeness of his forecast, and, therefore, reducing the quality of the manager's report. On the other hand, the direct effect associated to an increase in the prior precision augments the quality of the manager's report because his average estimate of the fundamental earnings improves. Nevertheless, an increase in the precision of the prior necessarily increases the quality of the manager's earnings report because the direct effect outweighs the indirect effect.

The final comparative static to be examined in relation to the quality of the manager's report is the one with respect to the precision p_m:

$$\frac{dQ_m}{dp_m} = \frac{\partial Q_m}{\partial p_a}\frac{dp_a}{dp_m} + \frac{\partial Q_m}{\partial p_m} = \frac{2(1-\gamma)^2 q\big(q^2+\gamma^2(p^2-q^2)\big)}{(2(1-\gamma)^2(p^3-q^3)+c_a q^3 p^3)p^2} + \frac{1-\gamma^2}{p^2} > 0. \quad (4.52)$$

Evidently, the quality of the manager's earnings report rises in the precision of the manager's private signal. Here, the direct effect of an increase in the manager's private signal precision, and the indirect effect through the precision of the analyst's private signal are both positive. The table 4 summarises the comparative statics of the quality of the manager's earnings report.

	p_θ	p_m	γ	c_a
Q_m	$+$	$+$	$-$	$-$

Table 4: Comparative statics of the manager's earnings report quality

To this point, the comparative static properties of the analyst's private signal precision, the quality of the analyst's forecast, and the quality of the manager's earnings report have been analysed. The last set of comparative static exercises to be considered reveal how changes in the exogenous parameters affect the expected utility of the analyst. Recall that the analyst's expected utility corresponds to minus the average squared distance between his forecast and the manager's earnings report. Formally, the expected utility of the analyst can be expressed in terms of the fundamental parameters:[73]

$$\begin{aligned} R_a &= E(\tilde{U}_a) = E(-(\tilde{r}_m - \tilde{r}_a)^2) \\ &= -\frac{(1-\gamma)^2 p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)}. \end{aligned} \tag{4.53}$$

The expected utility in equation (4.53) provides the basis for the subsequent analysis. To begin, the influence of the cost parameter c_a on the analyst's expected utility is considered. The cost parameter, c_a, only affects the analyst's expected utility, R_a, indirectly through the precision p_a. In addition, recall that a rise in c_a leads to a decrease in p_a, and that a decrease in p_a leads to a fall in R_a. Therefore, a rise in c_a leads to a fall in R_a. Contrary to c_a, the remaining exogenous parameters, i.e., p_θ, p_a, and p_m, affect the analyst's expected utility both directly and indirectly. So, to evaluate the influence of the remaining exogenous parameters on the analyst's utility, the total derivative of R_a is required:

[73] See appendix G.

$$dR_a = \frac{\partial R_a}{\partial \gamma} d\gamma + \frac{\partial R_a}{\partial p_\theta} dp_\theta + \frac{\partial R_a}{\partial p_a} dp_a + \frac{\partial R_a}{\partial p_m} dp_m. \tag{4.54}$$

To see how the parameter γ affects the analyst's expected utility, both sides of the total derivative are divided by $d\gamma$. Given that $d\gamma/d\gamma = 1$, $dp_\theta/d\gamma = 0$, and $dp_m/d\gamma = 0$, the derivative of R_a with respect to γ takes the following form:

$$\begin{aligned} \frac{dR_a}{d\gamma} &= \frac{\partial R_a}{\partial \gamma} + \frac{\partial R_a}{\partial p_a}\frac{dp_a}{d\gamma} \\ &= \frac{2(1-\gamma)(p-q)}{pq} - \frac{2(1-\gamma)^3(p^2-q^2)^2}{(2(1-\gamma)^2(p^3-q^3)+c_a q^3 p^3)qp} > 0. \end{aligned} \tag{4.55}$$

At first glance, the sign of the derivative above seems ambiguous; however, in appendix H it is shown that it is necessarily greater than zero. An increase in γ has a direct and an indirect effect on the expected utility. It helps to consider them separately. The direct effect $\left(\frac{\partial R_a}{\partial \gamma} > 0\right)$ results from the manager's incentive to meet the analyst's forecast becoming more acute as γ increases. As a result, the analyst's forecast becomes more important in the manager's earnings report (higher ϕ_a). This, in turn, increases R_a by reducing the average distance between the analyst's forecast and the manager's earnings report. The indirect effect $\left(\frac{\partial R_a}{\partial p_a}\frac{dp_a}{d\gamma} < 0\right)$, on the other hand, occurs because the analyst anticipates that the manager's incentive to meet the forecast becomes more acute; therefore, he gathers less costly private information on the firm's fundamental earnings. So, the manager places less credence on the analyst's forecast which increases the average distance between the manager's report and the analyst's forecast. Since the two effects have opposite signs, they countervail each other. Nevertheless, the direct effect dominates because

$$\left|\frac{\partial R_a}{\partial \gamma}\right| > \left|\frac{\partial R_a}{\partial p_a}\frac{dp_a}{d\gamma}\right|. \tag{4.56}$$

Therefore, an increase in γ necessarily increases the analyst's expected utility, R_a. This is shown formally in appendix H.

The penultimate comparative static to be considered is the one that ties the analyst's expected utility to the prior precision, p_θ:

$$\frac{dR_a}{dp_\theta} = \frac{\partial R_a}{\partial p_\theta} + \frac{\partial R_a}{\partial p_a}\frac{dp_a}{dp_\theta} = \frac{(1-\gamma)^2(p^2-q^2)c_a qp}{2(1-\gamma)^2(p^3-q^3)+c_a q^3 p^3} > 0 \tag{4.57}$$

Similar to the previous comparative static, the direct and indirect effect have opposite signs. The direct effect of a reduction in the prior uncertainty (higher p_θ) leads to a lower weight on the new information in the manager's and the analyst's posterior expectation of the fundamental earnings. This is beneficial to the analyst (higher R_a) because it reduces the average distance between his forecast and the manager's report. The indirect effect, on the other hand, entails the analyst gathering less private information which counteracts the direct effect. Since the direct effect is stronger, an increase in the prior precision increases the analyst's expected utility.

The last comparative static to be considered in this section relates the analyst's expected utility to the manager's private signal precision:

$$\frac{dR_a}{dp_m} = \frac{\partial R_a}{\partial p_a}\frac{dp_a}{dp_m} + \frac{\partial R_a}{\partial p_m} = -(1-\gamma)^2\left(\frac{2(1-\gamma)^2(p-q)p^2+c_a q^3 p^3}{2(1-\gamma)^2(p^3-q^3)+c_a q^3 p^3}\right) < 0. \tag{4.58}$$

An increase in the precision of the manager's private signal makes him place more credence on his private signal. This is reflected in the earnings report by a higher ϕ_m and lower ϕ_a. To the analyst's displeasure, the lower weight on the analyst's signal increases the expected distance between his forecast and the manager's report. This direct effect is counteracted by the indirect effect: Since the analyst knows that the manager's private signal will on average lie closer to the true fundamental earnings, he responds by gathering more costly private information in an effort to minimize the expected distance between the manager's report and his forecast.

$$\left|\frac{\partial R_a}{\partial p_m}\right| > \left|\frac{\partial R_a}{\partial p_a}\frac{dp_a}{dp_m}\right| \tag{4.59}$$

Overall, the direct effect is stronger than the indirect effect, i.e., the analyst's utility loss tied to the manager's report moving closer to the fundamental earnings is greater than his utility benefit from counteracting this by gathering more info. A summary on the comparative statics regarding the analyst's expected utility is given in table 5.

	p_θ	p_m	γ	c_a
R_a	$+$	$-$	$+$	$-$

Table 5: Comparative statics of the analyst's expected utility

4.1.4 Summary

The model captures a manager who first receives information on the fundamental earnings of his firm and then publishes an earnings report. The manager's choice of earnings report is governed by two forces: first, his interest in communicating the fundamental earnings; and, second, his interest in meeting the analyst's forecast. There are two sources of information available to the manager: an accountant and a (short-horizon) analyst. There exists a (unique) equilibrium solution whose comparative static properties were analysed. The equilibrium characterises how much information is gathered by the analyst; and how the analyst and manager weigh available information in the earnings forecast and earnings report, respectively.

The amount of information gathered by the analyst is captured by the precision p_a. As is to be expected, the analyst gathers less when his prior improves (higher p_θ), or when the cost of gathering information rises (higher c_a). More compelling, however, are the comparative statics with respect to the manager's private information precision, and manager's incentive parameter. The analysis shows that the analyst gathers more information when the manager's private information precision, p_m, rises; or when the manager's incentive to meet the analyst's forecast, γ, falls. This occurs because, for a higher p_m or a lower γ, the manager places less weight on the analyst's forecast in his earnings report which, on average, increases the distance between the forecast and the earnings report. The analyst anticipates this and responds by gathering more information on the firm's fundamental earnings in $t = 0$.

Next, the comparative statics of the analyst's forecast quality, i.e., the variance of the distance between the fundamental earnings and the analyst's forecast, were analysed. The forecast quality improves when the prior precision increases, when the manager's private information precision increases, when the manager's incentive to meet the analyst's forecast decreases, or when the cost of gathering information on the fundamental earnings falls. Except for the prior precision, the exogenous parameters each only affect the forecast quality indirectly. The prior precision, however, has a direct and an indirect effect on the forecast quality. On one hand, the analyst places more weight (direct effect) on the prior information if the prior precision improves; on the other hand, the analyst gathers less information (indirect effect). Since the direct effect is stronger than the indirect effect, the distance between the forecast and the fundamental earnings decreases (on average) with a rise in the prior precision.

Analogous to the forecast quality, the manager's earnings report quality is defined as the variance of the distance between the fundamental earnings and the earnings report. The results show that the comparative statics of the manager's earnings report quality have the same sign as the ones of the analyst's forecast quality. Said differently, the direction in which the forecast quality and earnings report quality respond to changes in the exogenous parameters is identical. However, the manager's private information precision, p_m, and his incentive to meet the analyst's forecast, γ, affect the earnings report quality both directly and indirectly. More specifically, the earnings report quality improves with a rise in the manager's private information precision which is the result of a direct and an indirect effect. The direct effect arises from the manager's improved ability to predict the firm's fundamental earnings. The indirect effect complements the direct effect and arises from the analyst's heightened incentive to gather more costly information. Contrarily, an increase in the manager's incentive to meet the analyst's forecast reduces the earnings report quality. The direct effect arises from the manager placing too much weight on the earnings forecast which reduces the earnings report quality. The analyst anticipates that the manager has a higher incentive to meet his forecast which results in an indirect effect: the analyst's incentive to gather costly private information falls. The direct and indirect effect complement each other and lead to a fall in the quality of the manager's earnings report.

4.2 Meeting the Forecast of a Long-Horizon Analyst

The model in section 4.1 considered a short-horizon analyst whose objective was to publish an earnings forecast that, on average, minimises the distance to the manager's earnings report. This section, on the other hand, considers an analyst with a long forecast horizon. Unlike the short-horizon analyst, the long-horizon analyst's objective is to publish an earnings forecast that, on average, minimises the distance to the firm's fundamental earnings. Besides exchanging the short-horizon analyst for a long-horizon analyst, the setting considered in section 4.1 remains the same throughout the present section.

This section is structured as follows. First, in section 4.2.1, the model from section 4.1 is adjusted to account for a long-horizon analyst. Section 4.2.2, derives the equilibrium of the model. Then, section 4.2.3, considers the comparative statics of the equilibrium. Finally, in section 4.2.4, the results are summarised.

4.2.1 Setup

Consistent with the setup of the previous model described in section 4.1.1, a manager who publishes an earnings report, $r_m \in (-\infty, \infty)$, is considered. As before, the firm yields fundamental earnings of $\tilde{\theta}$. The manager's and analyst's priors for $\tilde{\theta}$ are normally distributed with mean zero and precision $p_\theta \equiv 1/\sigma_\theta^2$. The manager receives information about the firm's fundamental earnings from the firm's accountant and an analyst. However, contrary to the previous model, the analyst is assumed to have a long forecast horizon. Note that in the previous section the subscript "a" was attributed to the short-horizon analyst, whereas the subscript "b" used hereafter is attributed to the long-horizon analyst.

To begin, the utility function of the long-horizon analyst is introduced. If θ and $r_b \in (-\infty, \infty)$ denote the realisations of the fundamental earnings and the long-horizon analyst's forecast, respectively, then the long-horizon analyst's utility is given by the following equation:

$$U_b = -(\theta - r_b)^2. \tag{4.60}$$

The long-horizon analyst's utility function is equal to minus the squared distance between the realisation of the firm's fundamental earnings, θ, and the forecast issued by the analyst, r_b. Hence, contrary to the short-horizon analyst considered previously, the long-horizon analyst is rewarded for publishing a forecast that lies close to the firm's fundamental earnings. Since the current model centres around the long-horizon analyst, he will, for the purpose of brevity, simply be referred to as the analyst in section 4.2.

The manager's utility function remains identical in structure to the one studied earlier in equation (4.2). If the realisations of the firm's fundamental earnings and the analyst's signal are θ and r_b, respectively, then the manager's utility is given by

$$U_m = -(1-\gamma)(\theta - r_m)^2 - \gamma(r_b - r_m)^2. \tag{4.61}$$

The utility consists of two terms: a quadratic loss in the squared distance between the fundamental earnings and the reported earnings; and a quadratic loss in the distance between the analyst's forecast and the reported earnings. The scale parameter γ determines the extent to which each term contributes to the manager's utility, and it is assumed that $0 \leq \gamma < 1$. The difference compared to the previous model is that the analyst's choice of earnings forecast, r_b, is underpinned by a different utility function.

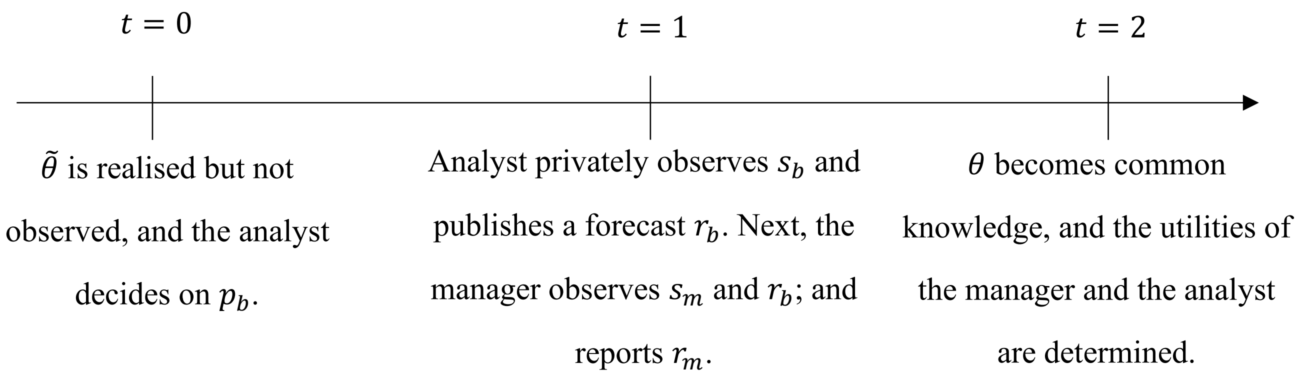

Figure 5: Timeline of events for the model with a long-horizon analyst

Compared to the previous model, the analyst's utility function is the only change made to the structure of the model presented here. A summary of the timeline of events is included in figure 5. In the remainder of this section, the structure of information available to the manager and timeline of events are described. Since the model presented in this section is closely related to the previous one, the remaining components are described only briefly because they have been discussed at length in section 4.1.1.

In $t = 0$, the fundamental earnings are realised, $\tilde{\theta} = \theta$, but the realisation of the fundamental earnings remains unobserved until $t = 2$. Moreover, the analyst decides on how much information to gather on the firm's fundamental earnings. Gathering more information entitles the analyst to a more precise private signal in $t = 1$. The structure of the analyst's private signal is given by

$$\tilde{s}_b = \tilde{\theta} + \tilde{\varepsilon}_b, \tag{4.62}$$

where $\tilde{\varepsilon}_b$ is normally distributed, independent of $\tilde{\theta}$, with mean zero and variance σ_b^2. The precision of the analyst's signal is $p_b \equiv 1/\sigma_b^2$. The feature that allows the analyst to improve the signal in $t = 0$ is borrowed from the previous model. Thus, as before, the analyst can choose to increase the precision of his private signal, $\tilde{s}_b$, at the cost of

$$C_b(p_b) = \frac{1}{2} c_b p_b^2, \tag{4.63}$$

where $c_b > 0$ is the analyst's idiosyncratic cost parameter.

In $t = 1$, the analyst observes the realisation of his private signal, s_b, and, afterwards, he publishes the earnings forecast, r_b. The manager, in turn, observes a private signal, s_m, and the analyst's forecast, r_b. Formally, the manager's private signal is given by

$$\tilde{s}_m = \tilde{\theta} + \tilde{\eta}, \tag{4.64}$$

where the measurement noise $\tilde{\eta}$ is normally distributed, independent of $\tilde{\theta}$, with mean zero and variance σ_η^2. The precision of $\tilde{s}_m$ is given by $p_m \equiv 1/\sigma_\eta^2$. After observing s_m and r_b, the manager proceeds to publish an earnings report, r_m. From equation (4.60), it is easy to see that, contrary to the model in section 4.1, the analyst's utility function does not depend on the manager's earnings report. This greatly simplifies the calculation of the analyst's earnings forecast, r_b, in the next section.

Finally, in $t = 2$, the fundamental earnings become public knowledge $\tilde{\theta} = \theta$, and the manager's utility $\widetilde{U}_m = U_m$ is determined. Afterwards, the game ends. Unless otherwise stated, all aspects of the model are commonly known.

4.2.2 Equilibrium

In this section, the equilibrium for the setup described in the preceding section is determined. This is accomplished in two steps. First, the manager's optimal report for a given pair of signals in $t = 1$ is derived; and, second, the optimal degree of information acquisition by the analyst in $t = 0$ is determined. Since the analyst's utility is independent from the manager's utility, the computation of the equilibrium solution is less complex compared to the previous model in section 4.1. The earnings forecast published by the long-horizon analyst takes the following linear form:

$$r_b = \Psi_0 + \Psi_b s_b, \tag{4.65}$$

where Ψ_0 accommodates for any constant term in the analyst's forecast; and Ψ_b is the value relevance of the analyst's private signal, s_b, in the forecast. It will become clear on page 75, that the linear form in equation (4.65) emerges endogenously.

As a first step, the earnings report that maximises the manager's expected utility conditional on the signals provided by the accountant and the analyst is determined. Formally, the maximisation problem is given by

$$\max_{r_m} E\left(-(1-\gamma)\left(\tilde{\theta} - r_m\right)^2 - \gamma(r_b - r_m)^2 \middle| r_b, s_m\right). \tag{4.66}$$

Besides the analyst forecast r_b, the manager's optimisation problem is identical to the one considered in equation (4.8). Thus, the manager's optimal earnings report is calculated analogously to (4.11) and yields:

$$r_m = (1-\gamma)E\left(\tilde{\theta} \middle| r_b, s_m\right) + \gamma r_b \tag{4.67}$$

Now, the conditional expectation $E(\tilde{\theta}|r_b, s_m)$ in the manager's earnings report in (4.67) needs to be calculated. Except for the notation, the calculation of $E(\tilde{\theta}|r_b, s_m)$ is identical to the calculation of $E(\tilde{\theta}|r_a, s_m)$ in appendix F. Thus, the conditional expectation $E(\tilde{\theta}|r_b, s_m)$ yields

$$E(\tilde{\theta}|r_b, s_m) = \frac{p_b(r_b - \Psi_0) + \Psi_b p_m s_m}{\Psi_b(p_\theta + p_b + p_m)}. \tag{4.68}$$

Afterwards, equation (4.68) is substituted into the manager's earnings report in equation (4.67) which yields

$$r_m = \frac{-(1-\gamma)\Psi_0 p_b}{\Psi_b(p_\theta + p_b + p_m)} + \left(\frac{(1-\gamma)p_b}{\Psi_b(p_\theta + p_b + p_m)} + \gamma\right) r_b + \frac{(1-\gamma)p_m}{p_\theta + p_b + p_m} s_m. \tag{4.69}$$

Since the manager's optimisation problem is similar to the one in the previous model, the computation of the equilibrium solution has, to this point, closely followed the steps in section 4.1.2. Moving forward, however, the computation of the equilibrium takes a new direction.

The current model considers a long-horizon analyst whose utility function is characterised by equation (4.60). Since the analyst faces uncertainty concerning the firm's fundamental earnings, his objective is given by

$$\max_{r_b} E\left(-\left(\tilde{\theta} - r_b\right)^2 \middle| s_b\right). \tag{4.70}$$

Hence, the analyst's objective is to publish a forecast that minimises the expected distance between his earnings forecast, r_b, and the firm's fundamental earnings, $\tilde{\theta}$, conditional on the realisation of the his private signal, s_b. By expanding the brackets and carrying through the expectation operator, the maximisation problem in equation (4.70) can be rewritten as

$$\max_{r_b} -E(\tilde{\theta}^2|s_b) + 2E(\tilde{\theta}|s_b)r_b - r_b^2. \tag{4.71}$$

To obtain the first order necessary condition from the maximisation problem in (4.71), the first derivative with respect to r_b is set equal to zero:

$$2E(\tilde{\theta}|s_b) - 2r_b = 0. \tag{4.72}$$

Rearranging the first order condition above with respect to r_b yields

$$r_b = E(\tilde{\theta}|s_b) = \frac{p_b}{p_\theta + p_b} s_b. \tag{4.73}$$

The second order condition for a maximum is satisfied because the second derivative of the analyst's expected utility with respect to the analyst forecast is smaller than zero: $d^2E(\tilde{U}_b|s_b)/dr_b^2 = -1$. It is easy to see that the computation of the analyst's report is less complex here compared to section 4.1.2 because the analyst's utility function does not depend on the manager's earnings report. Next, the constant term in equation (4.73) is set equal to Ψ_0, and the coefficient of the analyst's private signal in equation (4.73) is set equal to Ψ_b:

$$\begin{aligned} \Psi_0 &= 0, \text{and} \\ \Psi_b &= \frac{p_b}{p_\theta + p_b}. \end{aligned} \tag{4.74}$$

Substituting Ψ_0 and Ψ_b from (4.74) into the manager's earnings report in (4.69) yields

$$\begin{aligned} r_m &= \left(\frac{(1-\gamma)(p_\theta + p_b)p_b}{p_b(p_\theta + p_b + p_m)} + \gamma\right) r_b + \frac{(1-\gamma)p_m}{p_\theta + p_b + p_m} s_m \\ &= \left(\frac{p_\theta + p_b + \gamma p_m}{p_\theta + p_b + p_m}\right) r_b + \left(\frac{(1-\gamma)p_m}{p_\theta + p_b + p_m}\right) s_m. \end{aligned} \tag{4.75}$$

For $\gamma = 0$, the manager's objective reduces to minimising the distance between θ and r_m. In this case, the coefficients of r_b and s_m correspond to the Bayesian weights. Compared to the previous model, the analysts optimal forecast remains the same. However, as will become clear in a moment, the extent to which the analyst gathers information changes.

In stage $t = 0$, the analyst decides on the extent to which he should gather information on the fundamental earnings of the firm. To determine this, his expected utility needs to be calculated. This is accomplished by substituting the analyst's earnings forecast into his utility function:

$$\begin{aligned} E(\tilde{U}_b) &= -E\left((\tilde{\theta} - \tilde{r}_b)^2\right) \\ &= -Var\left(\tilde{\theta} - \frac{p_b}{p_\theta + p_b}(\tilde{\theta} + \tilde{\varepsilon}_b)\right) \\ &= -Var\left(\frac{p_\theta}{p_\theta + p_b}\tilde{\theta} - \frac{p_b}{p_\theta + p_b}\tilde{\varepsilon}_b\right) \end{aligned} \tag{4.76}$$

$$= -\left(\frac{p_\theta}{p_\theta + p_b}\right)^2 \frac{1}{p_\theta} - \left(\frac{p_b}{p_\theta + p_b}\right)^2 \frac{1}{p_b} = -\frac{1}{p_\theta + p_b}.$$

Compared to the expected utility in the previous model (see equation (4.31)), the structure of the expected utility above is less complex. Because, unlike in the previous model, the expected utility in (4.76) only depends on the prior precision and the precision of the analyst's private signal. The analyst chooses p_b to maximise his expected utility, net of costs. Formally, the maximisation problem is given by

$$\max_{p_b} -\frac{1}{p_\theta + p_b} - \frac{1}{2} c_b p_b^2. \tag{4.77}$$

The first order condition that arises from the maximisation problem in equation (4.77) is

$$\frac{1}{(p_\theta + p_b)^2} - c_b p_b = 0. \tag{4.78}$$

The condition in equation (4.78) states that the marginal expected utility must be equal to the marginal cost tied to gathering information. The second derivative of the analyst's objective function with respect to p_b is necessarily negative:

$$-\frac{2}{(p_\theta + p_b)^3} - c_b < 0. \tag{4.79}$$

Therefore, the p_m that solves equation (4.78) leads to a maximum. Finally, it remains to prove that there exists a unique solution to the equation. The left side of equation (4.78) tends towards $-\infty$ as the precision p_b approaches $+\infty$, is positive for $p_b = 0$, and decreases monotonically in p_b.[74] Therefore, there exists a unique positive real solution that solves equation (4.78).

To summarise, in an equilibrium, the extent to which the analyst gathers information in $t = 0$ is characterised implicitly by the unique solution, p_b, to

$$\frac{1}{(p_\theta + p_b)^2} - c_b p_b = 0. \tag{4.80}$$

[74] For a similar proof, see, for example, Fischer and Verrecchia (2000, p. 236).

The structure of the analyst's optimal earnings forecast and the manager's optimal earnings report in $t = 1$ is similar to the previous model. Hence, the analyst's optimal earnings forecast is given by

$$r_b = \frac{p_b}{p_\theta + p_b} s_b, \tag{4.81}$$

and the manager's optimal earnings report is given by

$$r_m = \left(\frac{p_\theta + p_b + \gamma p_m}{p_\theta + p_b + p_m}\right) r_b + \left(\frac{(1-\gamma)p_m}{p_\theta + p_b + p_m}\right) s_m. \tag{4.82}$$

This equilibrium solution is subject to a comparative static analysis in the next section.

4.2.3 Comparative Statics

In the preceding section, the equilibrium solution of the model was determined. Now, the influence of changes in the exogenous parameters on the equilibrium is analysed. As before in section 4.1.3, the optimal precision of the signal received from the accountant is characterised by an implicit function – see equation (4.80). Therefore, the method of implicit differentiation introduced in section 3.3 will be required again for the computation of the comparative statics. The detailed calculations of the comparative statics that follow are moved to appendix J. To economise notation, let $v \equiv p_\theta + p_b + p_m$, and $w \equiv p_\theta + p_b$.

Contrary to the short-horizon analyst considered in the previous model, the utility function of the long-horizon analyst in equation (4.60) is independent of the manager's earnings report, r_m. Consequently, the amount of information gathered by the analyst depends on neither the incentive parameter γ nor the precision p_m. Instead, equation (4.80) reveals that the optimal precision, p_b, only depends on the prior precision, p_θ, and the analyst's cost parameter, c_b. Below, the comparative statics of the optimal precision, p_b, with respect to these two parameters are analysed.

To evaluate, the influence of the cost parameter on the optimal precision, the derivative of p_b with respect to c_b is required:

$$\frac{dp_b}{dc_b} = \frac{-p_b(p_\theta + p_b)^3}{2 + (p_\theta + p_b)^3 c_b} < 0. \tag{4.83}$$

Similarly, to evaluate the influence of the prior precision on the optimal precision, the derivative of p_b with respect to p_θ is required:

$$\frac{dp_b}{dp_\theta} = \frac{-2}{2 + (p_\theta + p_b)^3 c_b} < 0. \tag{4.84}$$

The derivatives in equations (4.83) and (4.84) are both negative. Therefore, the extent to which the analyst gathers information on the firm's fundamental earnings decreases when the cost of gathering information increases, or when the analyst has more precise prior information on the firm's fundamental earnings. These results are consistent with the results of the previous model.[75] This is to be expected because both the short-horizon and long-horizon analyst share the interest for predicting the firm's fundamental earnings. Table 6 below features an overview of the results.

	p_θ	c_b
p_b	$-$	$-$

Table 6: Comparative statics of the long-horizon analyst's private signal precision.

Now, the forecast quality, Q_b, and expected utility, R_b, of the analyst are analysed. They can be considered together because, for the long-horizon analyst, they are identical.[76] To see this, recall that the expected utility, denoted R_b, is equal to minus the expectation of the squared distance between the fundamental earnings, $\tilde{\theta}$, and the analyst's earnings forecast, $\tilde{r}_b$, which is equivalent to the definition of the quality measure introduced in equation (4.42). Therefore, the forecast quality and expected utility are characterised by

$$\begin{aligned} R_b = Q_b &= -E^2(\tilde{\theta} - \tilde{r}_b) \\ &= -Var(\tilde{\theta} - \tilde{r}_b) = -\frac{1}{p_\theta + p_b}. \end{aligned} \tag{4.85}$$

[75] See table 2.

[76] This is in contrast to the short-horizon analyst considered earlier because his forecast quality and expected utility given in equations (4.42) and (4.53), respectively, were different.

The analysis of (4.85) yields insight into how the analyst's expected utility and his reporting quality are affected by changes in the exogenous parameters. Since equations (4.80) and (4.85) do not depend on the precision p_m or the parameter γ, these parameters have no influence on the analyst's optimal degree of information acquisition. The prior precision, p_θ, and the cost parameter, c_b, on the other hand, do have an influence. So, in the following, the comparative statics of R_b (or, equivalently, Q_b) with respect to p_θ and c_b are analysed.

The cost parameter, c_b, only affects the analyst's expected utility, R_b, indirectly through p_b. Therefore, the influence of c_b on R_b can be determined at first glance. Equation (4.83) shows that an increase in c_b leads to a decrease in p_b, and equation (4.85) shows that a decrease in p_b leads to a fall in R_b. This means that the analyst's expected utility, R_b, falls in the cost parameter, c_b. Said differently, if it becomes more costly to gather information on the fundamental earnings, the analyst gathers less which, on average, increases the expected distance between the fundamental earnings and the analyst's report.

The prior precision, p_θ, affects the analyst's expected utility, R_b, directly and indirectly. To see this, the derivative of R_b with respect to p_θ needs to be computed. To obtain this derivative, the total derivative of R_b, given by

$$dR_b = \frac{\partial R_b}{\partial p_\theta} dp_\theta + \frac{\partial R_b}{\partial p_b} dp_b, \tag{4.86}$$

is divided by dp_θ on both sides. Since $dp_\theta / dp_\theta = 1$, the derivative of R_b with respect to p_θ is

$$\frac{dR_b}{dp_\theta} = \frac{\partial R_b}{\partial p_\theta} + \frac{\partial R_b}{\partial p_b} \frac{dp_b}{dp_\theta}. \tag{4.87}$$

Solving the right side of the derivative in equation (4.87) explicitly yields

$$\frac{dR_b}{dp_\theta} = \frac{1}{(p_\theta + p_b)^2} \left(\frac{(p_\theta + p_b)^3 c_b}{2 + (p_\theta + p_b)^3 c_b} \right) > 0 \tag{4.88}$$

The sign of the derivative in (4.88) is positive, so an increase in the prior precision, p_θ, increases the analyst's expected utility, R_b, in an equilibrium. There are, however, two countervailing forces. On one hand, the direct effect $\left(\frac{\partial R_b}{\partial p_\theta} > 0\right)$ increases the analyst's expected utility by reducing the prior uncertainty surrounding the firm's fundamental earnings. On the other hand, the indirect effect $\left(\frac{\partial R_b}{\partial p_b}\frac{dp_b}{dp_\theta} < 0\right)$ decreases the analyst's expected utility because, given a higher prior information precision, the analyst gathers less (costly) private information on the fundamental earnings. Overall, the direct effect dominates the indirect effect because

$$\left|\frac{\partial R_b}{\partial p_\theta}\right| > \left|\frac{\partial R_b}{\partial p_b}\frac{dp_b}{dp_\theta}\right|. \tag{4.89}$$

Hence, an increase in prior precision necessarily leads to an increase in the analyst's expected utility. The comparative statics of R_b and Q_b are summarised in table 7 below.

	p_θ	c_b
Q_b (and R_b)	$+$	$-$

Table 7: Comparative statics of the long-horizon analyst's forecast quality

Last, the comparative static properties of the quality of the manager's earnings report are analysed. Conveniently, the manager's earnings report in equation (4.82) is identical to the one considered in the previous model in section 4.1. Therefore, the quality of the manager's earnings report is computed analogously to (4.47) which yields

$$Q_m = -\frac{p_\theta + p_b + \gamma^2 p_m}{(p_\theta + p_b + p_m)(p_\theta + p_b)}. \tag{4.90}$$

Several comparative static properties of Q_m can be determined at first glance. The incentive parameter γ and the manager's private information precision, p_m, each only have a direct effect on the on the quality of the manager's earnings report. An increase in γ leads to a decrease in Q_m because the manager places too much credence on the analyst's forecast which, on average, increases the distance between his forecast and the firm's fundamental earnings. Contrarily, an increase in p_m increases Q_m because it reduces the manager's uncertainty concerning the fundamental earnings. Unlike γ and p_m, the cost parameter, c_b, only affects Q_m indirectly through p_a:

$$\frac{dQ_m}{dc_b} = \frac{\partial Q_m}{\partial p_b}\frac{dp_b}{dc_b} = -\frac{w^2 + \gamma^2(v^2 - w^2)}{v^2}\left(\frac{p_b w^3}{2 + w^3 c_b}\right) < 0. \tag{4.91}$$

The derivative in equation (4.91) has a negative sign, so a rise in the cost parameter, c_b, reduces the quality of the manager's earnings report, Q_m. This result is intuitive because, given a higher cost of gathering information, the analyst will gather less information on the fundamental earnings; and, therefore, the manager receives a less informative forecast from the analyst which, in turn, reduces the quality of his earnings report.

The only exogenous parameter that has a direct and an indirect influence on the quality of the manager's earnings report, Q_m, is the prior precision, p_θ. To analyse the relationship between Q_m and p_θ, the following derivative is required:

$$\frac{dQ_m}{dp_\theta} = \frac{\partial Q_m}{\partial p_\theta} + \frac{\partial Q_m}{\partial p_b}\frac{dp_b}{dp_\theta} = \frac{w^2 + \gamma(v^2 - w^2)}{v^2}\left(\frac{wc_a}{2 + w^3 c_a}\right) > 0. \tag{4.92}$$

The derivative in equation (4.92) is positive, so the quality of the manager's earnings report rises in the prior precision. The direct effect $\left(\frac{\partial Q_m}{\partial p_\theta} > 0\right)$ improves the quality of the earnings report by reducing the prior uncertainty concerning the fundamental earnings. However, the indirect effect $\left(\frac{\partial Q_m}{\partial p_b}\frac{dp_b}{dp_\theta} < 0\right)$ reduces the quality of the report because, given the higher prior precision, the analyst gathers less private information which makes his forecast less informative for the manager. The comparative statics concerning Q_m are summarised below in table 8.

	p_θ	p_m	γ	c_a
Q_m	$+$	$+$	$-$	$-$

Table 8: Comparative statics of the manager's earnings report quality

4.2.4 Summary

In this section, a variation of the model proposed in section 4.1 is considered. Unlike section 4.1, the analyst considered in this section has a long forecast horizon. The long-horizon analyst's objective is to publish a forecast that lies as close as possible to the firm's fundamental earnings. The manager's objective, on the other hand, remains unchanged compared to section

4.1. For the new variation of the model considered in this section, the existence of a unique equilibrium solution was shown, and the comparative static properties were analysed.

Unlike the short-horizon analyst's objective, the long-horizon analyst's objective does not depend on the manager's earnings report. Consequently, the amount of information gathered by the long-horizon analyst only depends on the precision of his prior and the cost of gathering information. This makes the analysis of the comparative static properties much easier compared to section 4.1. As should be expected, the amount of information gathered by the long-horizon analyst, p_a, increases when the precision of his prior information, p_θ, decreases; or when the cost of acquiring information, c_b, decreases.

Similar to the amount of information gathered by the long-horizon analyst, the long-horizon analyst's forecast quality, Q_b, is also independent of the manager's earnings report. As a result, both the incentive parameter γ and precision p_m do not have an influence on the analyst's forecast quality, whereas the prior precision, p_θ, and cost of gathering information, c_b, do. The comparative statics reveal that an increase in the prior precision affects the forecast quality directly and indirectly. The direct effect is positive because, in response to a higher prior precision, the analyst's weight on his prior increases which, on average, closes the gap between the fundamental earnings and the analyst's forecast. The indirect effect, however, is negative because the analyst's incentive to privately gather information on the fundamental earnings falls. Since the direct effect is stronger than the indirect effect, a rise in the prior precision increases the analyst's forecast quality. An increase in the cost of acquiring information, in turn, only has an indirect effect on the analyst's forecast quality. Specifically, if gathering information becomes more costly (higher c_b), the analyst gathers less (lower p_b) which reduces the forecast quality. It is convenient that the analyst's expected utility is identical to his forecast quality because the comparative static results above also apply to the analyst's expected utility.

Last, the comparative statics of the manager's earnings report quality were considered. A rise in the prior precision has a positive direct and a negative indirect effect on the quality. Since the former outweighs the latter, a rise in the prior precision increases the quality of the earnings report. The cost of gathering information only has an indirect effect on the earnings report quality. If gathering information becomes more costly, the analyst's forecast becomes less informative to the manager because the analyst gathers less information on the firm's fundamental earnings. This has a negative effect on the quality of the manager's earnings report. Both the precision p_m and parameter γ only have a direct effect on the quality. A rise in p_m increases the manager's reliance on his private information, and a fall in γ reduces the manager's incentive to meet the analyst's forecast. Both, on average, reduce the distance between the manager's earnings report and the fundamental earnings leading to a rise in the earnings report quality.

4.3 Discussion

The models presented in sections 4.1 and 4.2 frame an earnings management setting in which a manager has the incentive to meet the forecast of an analyst. Despite the numerous assumptions that are required, the model captures the primary interdependencies that govern the extent to which an analyst gathers information in a setting where earnings are managed to meet the forecast of an analyst. In the following, the assumptions and limitations of the models are discussed.

A Comparison to the Model of Cheng et al. (2006)

This chapter proposed a model of earnings management that builds on the model of Cheng et al. (2006). The model of Cheng et al. (2006) considers how buy-side and sell-side analysts affect the investment decision of a fund manager. The extended model, in turn, frames an earnings management setting where a firm's manager employs earnings management to meet the forecast of an analyst. To compare the structure of the models, it helps to briefly consider them from a more abstract viewpoint. If the economic context is stripped away, both models consider a setting with a receiver who obtains information from two senders and then takes an action. The senders differ in type: one sender, the internal sender, is internal to the firm of the receiver because he is employed by the receiver, whereas the other sender, the external sender, does not belong to the firm of the receiver. Table 9 below provides an overview that maps the abstract designations to the players considered in the model of Cheng et al. (2006) and the extended model.

<table>
<tr><th rowspan="2">Abstract Designation</th><th rowspan="2">Cheng et al. (2006)</th><th colspan="2">Extended Model</th></tr>
<tr><th>Section 4.1</th><th>Section 4.2</th></tr>
<tr><td>External Sender</td><td>Sell-Side Analyst</td><td>Short-Horizon Analyst</td><td>Long-Horizon Analyst</td></tr>
<tr><td>Internal Sender</td><td>Buy-Side Analyst</td><td colspan="2">Accountant</td></tr>
<tr><td>Receiver</td><td>Fund Manager</td><td colspan="2">Manager</td></tr>
</table>

Table 9: Overview of players

Apart from the economic context, there are three key differences between the model of Cheng et al. (2006) and the extended model. First, compared to the model of Cheng et al. (2006), the utility function of the receiver in the extended model is more elaborate. Second, in the model of Cheng et al. (2006), the information acquisition decision of the internal sender is endogenized, whereas, in the extended model, the information acquisition decision of the external sender is endogenized. Third, and last, the structure of the signal communicated by the external sender is given exogenously in Cheng et al.'s (2006) model, whereas, in the extended model, it emerges endogenously as the result of the external sender's maximisation problem.

Structure of the Manager's Utility Function

In the model, the utility function of the manager that determines his choice of earnings report takes the following form:

$$U_m = -(1-\gamma)(\theta - r_m)^2 - \gamma(r_a - r_m)^2. \tag{4.93}$$

The first term of the utility function incentivises the manager to publish an earnings report that lies close to the fundamental earnings; and the second term incentivises the manager to meet the forecast of an analyst.[77] Although this utility function is highly stylized, it allows for the model to remain simple and for the comparative static properties of the equilibrium to be determined.

There is ample empirical evidence to support the claim that managers have strong incentives to meet analysts' expectations by, for example, meeting the consensus earnings forecasts.[78] The incentive to meet these expectations is particularly acute for managers of public firms because the market penalizes the firms that do not.[79] Thus, the use of earnings management among managers of public firms is unsurprising as it provides a useful lever for adjusting earnings to a desired level.[80] On this basis, the theoretical literature on earnings management is generally centred around managers of public firms. Moreover, in these studies, the firm's market price is often a component of the manager's utility structure.[81] This is in contrast to the present study because in the extended model the market price of the firm does not play a role within the manager's utility function U_m.

Against this background, it helps to briefly consider the necessary assumptions that explain the absence of the market price from the manager's utility function in the extended model. It is assumed that the firm is publicly traded, that the manager does not own equity in the firm he manages, and that the manager's compensation does not depend on the firm's market price. Needless to say, these assumptions are critical as stock-based compensation schemes are widespread in practice and a driver for earnings management.[82] Nevertheless, these assumptions are necessary for the extended model to be developed. The extended model, in turn, allows us to study earnings management from an angle that remains underexamined in theoretical literature.

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[77] In this case, the short-horizon analyst because r_a is used.

[78] Refer to p. 24 for more on why managers meet analysts' forecasts.

[79] See Lopez and Rees (2002).

[80] Refer to section 2.2.

[81] See, for example, Ewert and Wagenhofer (2005); and Fischer and Verrecchia (2000).

[82] See, for example, Healy (1985); and Bergstresser and Philippon (2006).

The assumptions that the firm is publicly listed aligns well with the overall setting of the model. To see this, consider the following. Publicly listed firms are subject to disclosure regulations set by institutions such as the SEC that require the firm to report financial information to the public. Moreover, public firms are subject to significant scrutiny from analysts who publish forecasts on the firm's performance. So, the assumption that the firm is publicly listed, gives rise to the setting outlined in the extended model in which an analyst issues a forecast of firm performance.

For concreteness, it helps to briefly consider in more depth how the manager's utility function projects onto reality. The quadratic loss in the distance between the fundamental earnings and the manager's earnings report, i.e., the first term in U_m, can be read as the manager's litigation risks, or psychic cost of publishing an earnings report that deviates from the fundamental earnings. The quadratic loss in the distance between the analyst's forecast and the manager's earnings report, i.e., the second term in U_m, can be read as the cost to the manager's reputation from inaccurate prior communication to the market and the resulting misguidance of analysts. Said differently, missing the analyst's forecast may suggest that the manager is unable to accurately predict his firm's performance. If for example, the analyst's forecast of earnings lies far in excess of the manager's reported earnings, the manager may have expressed himself too optimistically about his firm's performance towards the analyst in the past.

Another aspect worthy of scrutiny is the assumption that the incentive parameter γ is strictly smaller than one. The case where $\gamma = 1$ is excluded because it is difficult to conceive of a situation in which the manager's reporting decision is completely disconnected from the firm's fundamentals. Moreover, in the model with the short-horizon analyst, another issue emerges. Specifically, if $\gamma = 1$, the manager's utility would reduce to $U_m = (r_a - r_m)^2$ and as a result he would simply publish an earnings report that corresponds to the analyst's forecast. The analyst's utility, in turn, would always attain a maximum because his forecast will always correspond to the manager's earnings report.

Utility Structure of the Short-Horizon and Long-Horizon Analysts

Prior research suggests that more accurate analysts enjoy greater professional recognition.[83] In addition, there exists strong empirical evidence to support the claim that less accurate analysts are at a higher risk of being terminated.[84] Therefore, it is reasonable to surmise that analysts have strong incentives to produce forecasts that are accurate. On this basis, it behoves to ask whether the utility functions of the short-horizon and long-horizon analysts adequately reflect this incentive. Prior empirical studies define the forecast accuracy as the absolute difference between the reported earnings and the earnings forecast.[85] Under this definition, the short-horizon analyst's utility structure clearly reflects the incentive to produce an accurate forecast because the utility rises when the distance between his forecast and the manager's earnings report closes.[86] However, the afore mentioned definition of forecast accuracy should be viewed critically because, although empirical researchers use reported earnings as a proxy for true fundamental earnings, reported earnings and true fundamental earnings can fall apart. After all, there is ample theoretical and empirical evidence to support the claim that earnings management – which induces a difference between fundamental and reported earnings – is a widespread practice among managers.[87] So, if the accuracy of an analyst's forecast is measured relative to fundamental earnings (instead of the reported earnings) of a firm, the utility structure of the long-horizon analyst is more fitting. In practice, the discrepancy between fundamental earnings and reported earnings is likely to remain unobservable to outsiders, particularly in the short-term.[88] Consequently, the present study has considered both a short-horizon analyst, who aims to forecast close to the reported earnings, and a long-horizon analyst, who aims to forecast close to the fundamental earnings.

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[83] See Stickel (1992).

[84] See Groysberg et al. (2011), and Hong et al. (2000).

[85] See, for example, Hou et al. (2012, p. 511).

[86] See equation (4.1).

[87] Refer to p. 20.

[88] This was precisely the case in the earnings management scandals of Wirecard, Parmalat, and Enron.

Market Price of the Firm

Although the manager's utility function does not depend on the firm's market price, it is worth briefly considering how the market price is set in this model. In accordance with the concept of semi-strong market efficiency proposed by Malkiel and Fama (1970), the market price is assumed to reflect all public information. Consider, for example, the case of the short horizon analyst. Since the short horizon analyst's earnings forecast, r_a, and the manager's earnings report, r_m, are communicated publicly, the price is equal to $E(\tilde{\theta}|r_a, r_m)$:

$$P = E(\tilde{\theta}|r_a, r_m)$$
$$= \frac{Cov(\tilde{\theta}, \tilde{r}_a)Var(\tilde{r}_m) - Cov(\tilde{\theta}, \tilde{r}_m)Cov(\tilde{r}_a, \tilde{r}_m)}{Var(\tilde{r}_a)Var(\tilde{r}_m) - \left(Cov(\tilde{r}_a, \tilde{r}_m)\right)^2} r_a$$
$$+ \frac{Cov(\tilde{\theta}, \tilde{r}_m)Var(\tilde{r}_a) - Cov(\tilde{\theta}, \tilde{r}_a)Cov(\tilde{r}_a, \tilde{r}_m)}{Var(\tilde{r}_a)Var(\tilde{r}_m) - \left(Cov(\tilde{r}_a, \tilde{r}_m)\right)^2} r_m.$$

The market price is frequently used to calculate the price efficiency. This measure yields insight concerning the extent to which public and private information are impounded in the price. Most frequently, the price efficiency is characterised as $Var(\tilde{\theta}|P)$. However, the calculation of the price in terms of the model's fundamental parameters yields terms that are difficult to compute. Consequently, the calculation of price efficiency and its comparative statics becomes untraceable.

Endogenous vs. Exogenous Information Acquisition by the Manager

In the extended model, the manager privately observes the accounted earnings from the firm's accountant. It is assumed that the precision of the firm's accounted earnings (captured by p_m) is exogenously given. This assumption should be viewed critically because, in practice, the measurement noise in the firm's accounting system, η, which governs the precision of the firm's accounted earnings is subject to the manager's discretion and the firm's controlling division. To defend the exogeneity of p_m in the extended model, one could surmise that standard setters set stringent accounting standards ex-ante which eliminate the manager's discretion over p_m. Although this assumption is slightly critical, it is required for the model to remain traceable.

Nevertheless, it is worth briefly considering the adjustments that need to be made to the extended model to endogenize p_m. This is an avenue worth exploring because there are perhaps other environments to which this model can be applied where modelling the precision p_m endogenously is a suitable structural choice.

The following briefly considers how the precision p_m can be endogenized in the extended model in section 4.1. Assume that both the short-horizon analyst and the firm's manager simultaneously decide on how much information should be gathered on the firm's fundamental earnings in $t = 0$. While the analyst gathers the information himself, the accountant gathers the information on behalf of the manager. The manager incurs a cost for delegating the process of gathering information to the accountant. Formally, the cost he incurs is given by

$$C_m(p_m) = \frac{1}{2} c_m p_m^2, \tag{4.94}$$

where c_m is the manager's idiosyncratic cost parameter. In $t = 0$, the manager maximises his expected utility, $E(U_m)$, net of costs.[89] The manager's maximisation problem is

$$\max_{p_m} -(1-\gamma)\frac{p_\theta + p_a + \gamma p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)} - \frac{1}{2} c_m p_m^2, \tag{4.95}$$

where the first and second terms represent the manager's expected utility and cost, respectively. By setting the first derivative of equation (4.95) equal to zero, the first order necessary condition for a maximum is obtained:

$$\frac{(1-\gamma)^2}{(p_\theta + p_a + p_m)^2} - c_m p_m = 0. \tag{4.96}$$

The condition above states that the marginal expected utility needs to be equal to the marginal cost in an equilibrium. Moreover, the second order sufficient condition for a maximum is fulfilled because the second derivative of equation (4.95) is necessarily negative:

$$\frac{-2(1-\gamma)^2}{(p_\theta + p_a + p_m)^3} - c_m < 0. \tag{4.97}$$

[89] The manager's expected utility is computed in appendix I.

As a result, the precision p_m that solves equation (4.96) is a maximum to the manager's optimisation problem in (4.95). This solution is unique because the left side of equation (4.96) decreases monotonically in p_m, approaches $-\infty$ as p_m approaches $+\infty$, and is positive for $p_m = 0$.

The implicit function that characterises the analyst's choice of precision p_a remains unaffected and is the unique solution to

$$\frac{(1-\gamma)^2((p_\theta + p_a + p_m)^2 - (p_\theta + p_a)^2)}{(p_\theta + p_a + p_m)^2(p_\theta + p_a)^2} - c_a p_a = 0, \tag{4.98}$$

which is identical to equation (4.33) considered earlier. Thus, the extent to which information is gathered in an equilibrium is characterised by a pair of precisions (p_m, p_a) that simultaneously solve equations (4.96) and (4.98). Unfortunately, neither equation can be solved explicitly which greatly complicates any further analysis. This concludes the considerations concerning the endogenization of the precision p_m in the model from section 4.1. The endogenization of the precision p_m in the extended model from section 4.2 can be accomplished analogously and is left out at this point.

4.4 Future Research

The relationship between analysts and managers has been subject to significant attention from academic research.[90] The model proposed in this thesis considers this relationship by assuming that the manager has an incentive to meet the forecast of an analyst when reporting earnings. There exist several areas that require further investigation to fortify the predictions made by the extended model. In addition, there are several ways in which this model can be extended that may yield additional insight.

First, the extended model assumes that the firm's manager does not own stock in his firm. This assumption is necessary to justify the omission of the market price within the manager's utility

[90] Refer to section 2.3.

function and to reduce complexity. As discussed earlier, this is a critical assumption and it warrants attention in future research.[91] On this basis, modifying the extended model to a setting where the market price of the firm plays a role in the manager's utility function could yield novel insight.

Moreover, both variants of the extended model discussed under sections 4.1 and 4.2 assume that the firm is covered by only one analyst, whereas firms are often covered by multiple analysts in practice. In the presence of multiple analysts, the manager may have an incentive to meet the average forecast across all analysts, i.e., the consensus forecast. If more than one analyst is included in the model, several assumptions concerning the behaviour of the analysts need to be addressed: Are there synergies between analysts when gathering information? Is the error in the private information across analysts correlated? Is the cost for gathering information on the firm's fundamental earnings identical across all analysts? Do analysts decide on the gathering of information simultaneously or sequentially?

Finally, the manager studied in the extended model can infer the analyst's private information from the earnings forecast because the structure of the analyst's utility function is common knowledge. However, prior theoretical studies, such as Callsen-Bracker (2007), argue that analysts have private motives that are unobservable to outsiders. If, for example, the analyst is employed by the bank that underwrites debt of the manager's firm, the analyst may be have an incentive to publish favourable reports to generate future business. Thus extending the model to a setting where the analyst's private information cannot inferred from his forecast, also presents an avenue for future research.

[91] Refer to page 85.

5 Conclusion

Analysts routinely communicate their expectations on a firm's performance by publishing earnings forecasts. Board members, investors, and outsiders perceive these forecasts as a valuable source of information. Prior research suggests that managers have strong incentives to report earnings that meet the analysts' forecasts.[92] Consequently, the practice of managing earnings to achieve this has become widespread among managers. However, the academic research to consider this from a theoretical perspective remains sparse. Against this background, this thesis proposes a novel model of earnings management, the "extended model", that builds on the work of Cheng et al. (2006).

The extended model considers a manager who reports earnings after receiving information from his accountant and an analyst. The manager's objective is not only to report the firm's fundamental earnings but also to meet the earnings forecast of a representative analyst. The first variant of the extended model assumes that the analyst's forecast horizon is short, that is, he aims to publish a forecast that lies as close as possible to the manager's reported earnings. The comparative static analysis of the equilibrium reveals that the extent to which the analyst gathers information on the firm's fundamental earnings falls when the precision of prior information increases, when the precision of the manager's private information falls, when the manager's incentive to meet the analyst's forecast increases, or when the analyst's cost of gathering information rises. Moreover, the quality of both the analyst's forecast and manager's earnings report respond identically to changes in the exogenous parameters. Specifically, the quality rises when the precision of prior information increases, when the precision of the manager's private information increases, when the manager's incentive to meet the analyst forecast falls, or when the analyst's cost of gathering information falls.

[92] Refer to p. 24.

Afterwards, a second variant of the extended model was considered in which the forecast horizon of the analyst was assumed to be long. The long-horizon analyst aims to publish a forecast that lies in close proximity to the firm's fundamental earnings. Unlike the short-horizon analyst, the extent to which the long-horizon analyst gathers information does not depend on either the precision of the manager's private information or his interest in meeting the analyst's forecast. Therefore, the analyst's forecast quality is unaffected by these parameters. Besides that, the direction in which the information acquisition by the analyst, the analyst's forecast quality, and the quality of the manager's earnings report respond to a change in the exogenous parameters is identical to the case of the short-horizon analyst.

A comparison of the results from both variants of the extended model reveals the following. The manager's incentive to meet the analyst's forecast is particularly relevant if the analyst's forecast horizon is short. This is because a rise in the manager's desire to meet the analyst's forecast reduces the extent to which the analyst gathers costly information on the firm's fundamental earnings. This has a negative impact on the quality of both the short-horizon analyst's earnings forecast and the manager's earnings report. Contrarily, if the analyst's forecast horizon is long, the manager's incentive to meet the analyst's forecast does not have an influence on the analyst's information acquisition decision.

6 Appendix

A. Formulae

Bayes' Law for Normally Distributed Random Variables

Assume that an agent's prior belief of the random variable $\tilde{h}$ is that it is normally distributed with mean μ_h and precision, i.e. inverse of the variance, p_h. Moreover, let there be a signal $\tilde{s} = \tilde{h} + \tilde{n}$ with the following properties: $\tilde{n} \sim N(0, p_n^{-1})$ and $E(\tilde{h}\tilde{n}) = 0$. Once the agent observes $\tilde{s} = s$, he forms a posterior belief about $\tilde{h}$. Using Bayes' Law, the posterior belief is that $\tilde{h}$ is normally distributed with a mean of

$$E(\tilde{h}|s) = \frac{p_h}{p_h + p_n}\mu_h + \frac{p_n}{p_h + p_n}s$$

and a variance of

$$Var(\tilde{h}|s) = \frac{1}{p_h + p_n}.$$

Note, the weights on μ_h and s in the posterior mean are equal to the relative precision of their respective distributions; and the precision of the posterior, i.e. $1/Var(\tilde{h}|s)$, is the sum of the prior precision and the signal precision: $p_h + p_n$. Given that the posterior distribution is normally distributed, the steps above can be iterated for a sequence of signals.[93]

Derivative of an Implicit Function

If the function $g = f(h)$ is implicitly characterised by $F(g, h) = 0$, then the derivative of g with respect to h is

$$\frac{dg}{dh} = -\frac{\partial F/\partial h}{\partial F/\partial g},$$

where $\partial F/\partial h$ and $\partial F/\partial g$ are the partial derivatives of F with respect to h and g, respectively.

[93] See Chamley (2004, pp. 25–26)

Conditional Expectation of Multivariate Normal Distribution

Assume $\tilde{x} \sim N(\mu_x, \sigma_x^2)$, $\tilde{y} \sim N(\mu_y, \sigma_y^2)$, and $\tilde{z} \sim N(\mu_z, \sigma_z^2)$. Then the conditional expectation of $\tilde{x}$ given $\tilde{y} = y$ is

$$E(\tilde{x}|y) = \mu_x + \frac{\sigma_{xy}}{\sigma_y^2}(y - \mu_y),$$

and the conditional expectation of $\tilde{x}$ given $\tilde{y} = y$ and $\tilde{z} = z$ is

$$E(\tilde{x}|y,z) = \mu_x + \frac{\sigma_{xy}\sigma_z^2 - \sigma_{xz}\sigma_{yz}}{\sigma_y^2\sigma_z^2 - \sigma_{yz}^2}(y - \mu_y) + \frac{\sigma_{xz}\sigma_y^2 - \sigma_{xy}\sigma_{yz}}{\sigma_y^2\sigma_z^2 - \sigma_{yz}^2}(z - \mu_z).$$

B. Calculation of the First Order Condition in Section 3.2

To begin, the expected utility conditional on the realised signals s_B and s_S is determined:

$$\begin{aligned}
E(\tilde{U}|s_B, s_S) &= E\left(-\kappa(\tilde{\theta} - a)^2 \middle| s_B, s_S\right) \\
&= E\left(-\kappa(\tilde{\theta}^2 - 2\tilde{\theta}a + a^2)\middle|s_B, s_S\right) \\
&= -\kappa E(\tilde{\theta}^2 - 2\tilde{\theta}a + a^2|s_B, s_S) \\
&= -\kappa\left(E(\tilde{\theta}^2|s_B, s_S) - 2aE(\tilde{\theta}|s_B, s_S) + a^2\right) \\
&= -\kappa E(\tilde{\theta}^2|s_B, s_S) + 2a\kappa E(\tilde{\theta}|s_B, s_S) - \kappa a^2.
\end{aligned}$$

Based on the calculation above, the first derivative of $E(\tilde{U}|s_B, s_S)$ with respect to a is

$$2\kappa E(\tilde{\theta}|s_B, s_S) - 2\kappa a.$$

Finally, setting the equation above equal to zero, and then simplifying yields the first order condition

$$E(\tilde{\theta}|s_B, s_S) - a = 0.$$

C. Calculation of $E(\tilde{\theta}|s_B, s_S)$ in Section 3.2

To compute the conditional expectation $E(\tilde{\theta}|s_B, s_S)$, two cases need to be addressed. The case where the external sender is unbiased, and the case where he is biased. Note, the superscript u

and b are used to denote an unbiased and a biased external sender, respectively. Thus, the signal from the unbiased external sender is

$$\tilde{s}_S^u = \tilde{\theta} + \tilde{\eta}_S,$$

and signal from the biased external sender is

$$\tilde{s}_S^b = \tilde{\theta} + \tilde{\eta}_S + \beta.$$

If the external sender is unbiased, the expected value of the true state conditional on s_B and s_S^u is given by

$$\begin{aligned} E\left(\tilde{\theta}\middle|s_B, s_S^u\right) = &\ \frac{\sigma_\theta^2\sigma_S^2}{\sigma_\theta^2\sigma_B^2 + \sigma_\theta^2\sigma_S^2 + \sigma_S^2\sigma_B^2} s_B + \frac{\sigma_\theta^2\sigma_B^2}{\sigma_\theta^2\sigma_B^2 + \sigma_\theta^2\sigma_S^2 + \sigma_S^2\sigma_B^2} s_S \\ &= \frac{p_B s_B + p_S s_S}{p_\theta + p_S + p_B}. \end{aligned}$$

Analogously, if the external sender is biased, the expected value of the true state conditional on s_B and s_S^b is

$$\begin{aligned} E\left(\tilde{\theta}\middle|s_B, s_S^b\right) &= \frac{\sigma_\theta^2\sigma_S^2}{\sigma_\theta^2\sigma_B^2 + \sigma_\theta^2\sigma_S^2 + \sigma_S^2\sigma_B^2} s_B + \frac{\sigma_\theta^2\sigma_B^2}{\sigma_\theta^2\sigma_B^2 + \sigma_\theta^2\sigma_S^2 + \sigma_S^2\sigma_B^2} (s_S - b) \\ &= \frac{p_B s_B + p_S(s_S - b)}{p_\theta + p_S + p_B}. \end{aligned}$$

The external sender is biased with probability $q \in (0,1)$ and unbiased with probability $1 - q$. So, if the decision maker does not know the external sender's type, the conditional expectation $E\left(\tilde{\theta}\middle|s_B, s_S\right)$ is given by

$$\begin{aligned} E\left(\tilde{\theta}\middle|s_B, s_S\right) &= qE\left(\tilde{\theta}\middle|s_B, s_S^b\right) + (1-q)E\left(\tilde{\theta}\middle|s_B, s_S^u\right) \\ &= q\left(\frac{p_B s_B + p_S(s_S - b)}{p_\theta + p_S + p_B}\right) + (1-q)\left(\frac{p_B s_B + p_S s_S}{p_\theta + p_S + p_B}\right) \\ &= \lambda_B s_B + \lambda_S(s_S - qb), \end{aligned}$$

where $\lambda_B = p_B/(p_\theta + p_S + p_B)$ and $\lambda_S = p_S/(p_\theta + p_S + p_B)$.

D. Expected Utility in Section 3.2

The decision maker's expected utility is given by

$$E(\tilde{U}) = E\left(-\kappa(\tilde{\theta} - a)^2\right)$$
$$= -\kappa\left(Var(\tilde{\theta} - a) + E^2(\tilde{\theta} - a)\right),$$

and the decision maker's optimal action is

$$a = \lambda_B s_B + \lambda_S(s_S - qb),$$

where $\lambda_B = p_B/(p_\theta + p_S + p_B)$ and $\lambda_S = p_S/(p_\theta + p_S + p_B)$.

To compute the expected utility, the optimal action is substituted into $Var(\tilde{\theta} - a)$ and $E^2(\tilde{\theta} - a)$, which yields

$$\begin{aligned}
Var(\tilde{\theta} - a) &= (1-q)Var\left(\tilde{\theta} - \lambda_B\tilde{s}_B - \lambda_S(\tilde{s}_S^u - qb)\right) + qVar\left(\tilde{\theta} - \lambda_B\tilde{s}_B - \lambda_S(\tilde{s}_S^b - qb)\right) \\
&= (1-q)Var\left(\tilde{\theta} - \lambda_B(\tilde{\theta} + \tilde{\eta}_B) - \lambda_S(\tilde{\theta} + \tilde{\eta}_S - qb)\right) \\
&\quad + qVar\left(\tilde{\theta} - \lambda_B(\tilde{\theta} + \tilde{\eta}_B) - \lambda_S(\tilde{\theta} + \tilde{\eta}_S + b - qb)\right) \\
&= \frac{(1 - \lambda_B - \lambda_S)^2}{p_\theta} + \frac{\lambda_B^2}{p_B} + \frac{\lambda_S^2}{p_S} \\
&= \frac{p_\theta}{(p_\theta + p_S + p_B)^2} + \frac{p_B}{(p_\theta + p_S + p_B)^2} + \frac{p_S}{(p_\theta + p_S + p_B)^2} \\
&= \frac{1}{p_\theta + p_S + p_B}, \text{ and}
\end{aligned}$$

$$\begin{aligned}
E^2(\tilde{\theta} - a) &= (1-q)E^2\left(\tilde{\theta} - \lambda_B\tilde{s}_B - \lambda_S(\tilde{s}_S^u - qb)\right) + qE^2\left(\tilde{\theta} - \lambda_B\tilde{s}_B - \lambda_S(\tilde{s}_S^b - qb)\right) \\
&= (1-q)E^2\left(\tilde{\theta} - \lambda_B(\tilde{\theta} + \tilde{\eta}_B) - \lambda_S(\tilde{\theta} + \tilde{\eta}_S - qb)\right) \\
&\quad + qE^2\left(\tilde{\theta} - \lambda_B(\tilde{\theta} + \tilde{\eta}_B) - \lambda_S(\tilde{\theta} + \tilde{\eta}_S + b - qb)\right) \\
&= (1-q)q^2b^2\lambda_S^2 + q(1-q)^2b^2\lambda_S^2 \\
&= \underbrace{q(1-q)b^2}_{\Sigma_\beta^2}\lambda_S^2 = \frac{p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^2}.
\end{aligned}$$

Next, the two terms computed previously are substituted into the expected utility:

$$E(\widetilde{U}) = -\kappa\left(Var(\tilde{\theta} - a) + E^2(\tilde{\theta} - a)\right) = -\kappa\left(\frac{1}{p_\theta + p_S + p_B} + \frac{p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^2}\right).$$

E. Comparative Statics of p_B in Section 3.3

The partial derivatives of $F(\kappa, p_\theta, p_S, p_B, \Sigma_\beta)$, which is given by the left-hand side of equation (3.11) are as follows:

$$F_{p_B} = -\kappa\left(\frac{2}{(p_\theta + p_S + p_B)^3} + \frac{6p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^4}\right) - C''(p_B),$$

$$F_\kappa = \frac{1}{(p_\theta + p_S + p_B)^2} + \frac{2p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^3},$$

$$F_{p_\theta} = -\kappa\left(\frac{2}{(p_\theta + p_S + p_B)^3} + \frac{6p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^4}\right),$$

$$F_{p_S} = \kappa\left(\frac{2p_S\Sigma_\beta^2(2p_\theta + 2p_B - p_S) - 2(p_\theta + p_S + p_B)}{(p_\theta + p_S + p_B)^4}\right), \text{and}$$

$$F_{\Sigma_\beta^2} = \frac{2p_S^2\kappa}{(p_\theta + p_S + p_B)^3}.$$

The derivatives of p_B with respect to the exogenous parameters are all determined using the formula for the "derivative of an implicit function" in appendix A and are as follows:

$$\frac{dp_B}{d\kappa} = \frac{\frac{1}{(p_\theta + p_S + p_B)^2} + \frac{2p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^3}}{\kappa\left(\frac{2}{(p_\theta + p_S + p_B)^3} + \frac{6p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^4}\right) + C''(p_B)}$$

$$= \frac{(p_\theta + p_S + p_B)^2 + 2p_S^2\Sigma_\beta^2(p_\theta + p_S + p_B)}{\kappa\left(2(p_\theta + p_S + p_B) + 6p_S^2\Sigma_\beta^2\right) + (p_\theta + p_S + p_B)^4 C''(p_B)}$$

$$\frac{dp_B}{dp_\theta} = \frac{-\kappa\left(\frac{2}{(p_\theta + p_S + p_B)^3} + \frac{6p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^4}\right)}{\kappa\left(\frac{2}{(p_\theta + p_S + p_B)^3} + \frac{6p_S^2\Sigma_\beta^2}{(p_\theta + p_S + p_B)^4}\right) + C''(p_B)}$$

$$= \frac{-\kappa\left(2(p_\Theta + p_S + p_B) + 6p_S^2\Sigma_\beta^2\right)}{\kappa\left(2(p_\Theta + p_S + p_B) + 6p_S^2\Sigma_\beta^2\right) + (p_\Theta + p_S + p_B)^4 C''(p_B)}$$

$$\frac{dp_B}{dp_S} = \frac{\kappa\left(\dfrac{2p_S\Sigma_\beta^2(2p_\Theta + 2p_B - p_S) - 2(p_\Theta + p_S + p_B)}{(p_\Theta + p_S + p_B)^4}\right)}{\kappa\left(\dfrac{2}{(p_\Theta + p_S + p_B)^3} + \dfrac{6p_S^2\Sigma_\beta^2}{(p_\Theta + p_S + p_B)^4}\right) + C''(p_B)}$$

$$= \frac{-\kappa\left(2(p_\Theta + p_S + p_B) - 2p_S\Sigma_\beta^2(2p_\Theta + 2p_B - p_S)\right)}{\kappa\left(2(p_\Theta + p_S + p_B) + 6p_S^2\Sigma_\beta^2\right) + (p_\Theta + p_S + p_B)^4\, C''(p_B)}$$

$$\frac{dp_B}{d\Sigma_\beta^2} = \frac{\dfrac{2p_S^2\kappa}{(p_\Theta + p_S + p_B)^3}}{\kappa\left(\dfrac{2}{(p_\Theta + p_S + p_B)^3} + \dfrac{6p_S^2\Sigma_\beta^2}{(p_\Theta + p_S + p_B)^4}\right) + C''(p_B)}$$

$$= \frac{2p_S^2\kappa(p_\Theta + p_S + p_B)}{\kappa\left(2(p_\Theta + p_S + p_B) + 6p_S^2\Sigma_\beta^2\right) + (p_\Theta + p_S + p_B)^4\, C''(p_B)}$$

F. Solving $E\left(\tilde{\theta}\middle|r_a, s_m\right)$ explicitly in Section 4.1.2

Computation of $E\left(\tilde{\theta}\middle|r_a, s_m\right)$ where $Cov(\tilde{r}_a, \tilde{s}_m) = \Omega_a\sigma_\theta^2$, $Var(\tilde{r}_a) = \Omega_a^2\left(\sigma_\theta^2 + \sigma_a^2\right)$, $Var(\tilde{s}_m) = \sigma_\theta^2 + \sigma_\eta^2$, $Cov\left(\tilde{\theta}, \tilde{s}_m\right) = \sigma_\theta^2$, and $Cov\left(\tilde{\theta}, \tilde{r}_a\right) = \Omega_a\sigma_\theta^2$.

$$E\left(\tilde{\theta}\middle|r_a, s_m\right) = \frac{\left(\Omega_a\sigma_\theta^2\left(\sigma_\theta^2 + \sigma_\eta^2\right) - \Omega_a\sigma_\theta^4\right)(r_a - \Omega_0)}{\left(\Omega_a^2\left(\sigma_\theta^2 + \sigma_a^2\right)\right)\left(\sigma_\theta^2 + \sigma_\eta^2\right) - \Omega_a^2\sigma_\theta^4} + \frac{\left(\sigma_\theta^2\left(\Omega_a^2\left(\sigma_\theta^2 + \sigma_a^2\right)\right) - \left(\Omega_a\sigma_\theta^2\right)^2\right)s_m}{\left(\Omega_a^2\left(\sigma_\theta^2 + \sigma_a^2\right)\right)\left(\sigma_\theta^2 + \sigma_\eta^2\right) - \Omega_a^2\sigma_\theta^4}$$

$$= \frac{\Omega_a\sigma_\theta^2\sigma_\eta^2(r_a - \Omega_0)}{\left(\Omega_a^2\left(\sigma_\theta^2 + \sigma_a^2\right)\right)\left(\sigma_\theta^2 + \sigma_\eta^2\right) - \Omega_a^2\sigma_\theta^4} + \frac{\Omega_a^2\sigma_a^2\sigma_\theta^2 s_m}{\left(\Omega_a^2\left(\sigma_\theta^2 + \sigma_a^2\right)\right)\left(\sigma_\theta^2 + \sigma_\eta^2\right) - \Omega_a^2\sigma_\theta^4}$$

$$= \frac{\Omega_a\sigma_\theta^2\sigma_\eta^2(r_a - \Omega_0) + \left(\Omega_a^2\sigma_a^2\sigma_\theta^2\right)s_m}{\Omega_a^2\left(\sigma_\theta^2 + \sigma_a^2\right)\left(\sigma_\theta^2 + \sigma_\eta^2\right) - \Omega_a^2\sigma_\theta^4}$$

$$= \frac{\left(\sigma_\theta^2\sigma_\eta^2\right)(r_a - \Omega_0) + \left(\Omega_a\sigma_a^2\sigma_\theta^2\right)s_m}{\Omega_a\left(\sigma_\theta^4 + \sigma_\theta^2\sigma_\eta^2 + \sigma_a^2\sigma_\theta^2 + \sigma_a^2\sigma_\eta^2\right) - \Omega_a\sigma_\theta^4}$$

$$= \frac{\left(\sigma_\theta^2\sigma_\eta^2\right)(r_a - \Omega_0) + \left(\Omega_a\sigma_a^2\sigma_\theta^2\right)s_m}{\Omega_a\left(\sigma_\theta^2\sigma_\eta^2 + \sigma_a^2\sigma_\theta^2 + \sigma_a^2\sigma_\eta^2\right)}$$

$$= \frac{\frac{(r_a - \Omega_0)}{\sigma_a^2} + \frac{\Omega_a s_m}{\sigma_\eta^2}}{\Omega_a \left(\frac{1}{\sigma_a^2} + \frac{1}{\sigma_\eta^2} + \frac{1}{\sigma_\theta^2} \right)}$$

$$= \frac{p_a (r_a - \Omega_0) + \Omega_a p_m s_m}{\Omega_a (p_\theta + p_a + p_m)}$$

G. Analyst's Expected Utility in Section 4.1.2

Recall that ϕ_0, ϕ_a, and ϕ_m are given in (4.30); and Ω_0, and Ω_a are given in (4.26) and (4.27), respectively.

$$E(-(\tilde{r}_m - \tilde{r}_a)^2) =$$

$$= E(-(\phi_0 + \phi_a \tilde{r}_a + \phi_m \tilde{s}_m - \Omega_a \tilde{s}_a)^2)$$

$$= E\left[- \left(\underbrace{\left(\frac{p_\theta + p_a + \gamma p_m}{p_\theta + p_a + p_m} \right) \underbrace{\left(\frac{p_a}{p_\theta + p_a} \right) \tilde{s}_a}_{\tilde{r}_a} + \frac{(1-\gamma) p_m}{p_\theta + p_a + p_m} \tilde{s}_m}_{\tilde{r}_m} - \underbrace{\frac{p_a}{p_\theta + p_a} \tilde{s}_a}_{\tilde{r}_a} \right)^2 \right]$$

$$= E\left[- \left(\frac{(p_\theta + p_a + \gamma p_m) p_a - p_a (p_\theta + p_a + p_m)}{(p_\theta + p_a + p_m)(p_\theta + p_a)} \tilde{s}_a + \frac{(1-\gamma) p_m}{p_\theta + p_a + p_m} \tilde{s}_m \right)^2 \right]$$

$$= E\left[- \left(\left(\frac{-(1-\gamma) p_a p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)} \right) \tilde{s}_a + \frac{(1-\gamma) p_m}{p_\theta + p_a + p_m} \tilde{s}_m \right)^2 \right]$$

$$= -\mathrm{Var}\left(\frac{-(1-\gamma) p_a p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)} \tilde{s}_a + \frac{(1-\gamma) p_m}{p_\theta + p_a + p_m} \tilde{s}_m \right)$$

$$= -(1-\gamma)^2 \mathrm{Var}\left(\frac{-p_a p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)} \left(\tilde{\theta} + \tilde{\varepsilon}_a \right) + \frac{p_m}{p_\theta + p_a + p_m} \left(\tilde{\theta} + \tilde{\eta} \right) \right)$$

$$= -(1-\gamma)^2 \mathrm{Var}\left(\begin{array}{c} \left(\frac{p_m (p_\theta + p_a) - p_a p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)} \right) \tilde{\theta} \\ + \left(\frac{-p_a p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)} \right) \tilde{\varepsilon}_a \\ + \frac{p_m}{p_\theta + p_a + p_m} \tilde{\eta} \end{array} \right)$$

$$= -(1-\gamma)^2 \mathrm{Var}\begin{pmatrix} \left(\frac{p_\theta p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)}\right)\tilde{\theta} \\ + \left(\frac{-p_a p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)}\right)\tilde{\varepsilon}_a \\ + \frac{p_m}{p_\theta + p_a + p_m}\tilde{\eta} \end{pmatrix}$$

$$= -(1-\gamma)^2 \begin{pmatrix} \left(\frac{p_\theta^2 p_m^2}{(p_\theta + p_a + p_m)^2(p_\theta + p_a)^2}\right)\frac{1}{p_\theta} \\ + \left(\frac{p_a^2 p_m^2}{(p_\theta + p_a + p_m)^2(p_\theta + p_a)^2}\right)\frac{1}{p_a} \\ + \frac{p_m^2}{(p_\theta + p_a + p_m)^2}\frac{1}{p_m} \end{pmatrix}$$

$$= -(1-\gamma)^2 \begin{pmatrix} \frac{p_\theta p_m^2}{(p_\theta + p_a + p_m)^2(p_\theta + p_a)^2} \\ + \frac{p_a p_m^2}{(p_\theta + p_a + p_m)^2(p_\theta + p_a)^2} \\ + \frac{p_m}{(p_\theta + p_a + p_m)^2} \end{pmatrix}$$

$$= -(1-\gamma)^2 \left(\frac{p_m^2(p_\theta + p_a)}{(p_\theta + p_a + p_m)^2(p_\theta + p_a)^2} + \frac{p_m}{(p_\theta + p_a + p_m)^2}\right)$$

$$= -(1-\gamma)^2 \left(\frac{p_m^2}{(p_\theta + p_a + p_m)^2(p_\theta + p_a)} + \frac{p_m(p_\theta + p_a)}{(p_\theta + p_a + p_m)^2(p_\theta + p_a)}\right)$$

$$= -(1-\gamma)^2 \left(\frac{p_m^2 + p_m(p_\theta + p_a)}{(p_\theta + p_a + p_m)^2(p_\theta + p_a)}\right) = -\frac{(1-\gamma)^2 p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)}$$

H. Comparative Statics for Section 4.1.3

The comparative static results of section 4.1.3 are derived and summarised below. Recall that for brevity of notation $p = p_\theta + p_a + p_m$ and $q = p_\theta + p_a$.

Required partial derivatives:

The partial derivatives of $F(p_\theta, p_a, p_m, \gamma, c_a)$, which is given by the left-hand side of (4.35) are

$$F_{c_a} = -p_a,$$

$$F_{p_a} = -\frac{2(1-\gamma)^2(p^3 - q^3)}{q^3 p^3} - c_a,$$

$$F_{p_\theta} = -\frac{2(1-\gamma)^2(p^3-q^3)}{q^3p^3},$$

$$F_{p_m} = \frac{2(1-\gamma)^2}{p^3}, \text{and}$$

$$F_\gamma = -\frac{2(1-\gamma)(p^2-q^2)}{q^2p^2}.$$

<u>Comparative statics of the precision p_a:</u>

$$\frac{dp_a}{dc_a} = -\frac{F_{c_a}}{F_{p_a}} = -\frac{-p_a}{-\frac{2(1-\gamma)^2(p^3-q^3)}{q^3p^3} - c_a} = \frac{-p_a q^3 p^3}{2(1-\gamma)^2(p^3-q^3) + q^3p^3c_a} < 0$$

$$\frac{dp_a}{dp_\theta} = -\frac{F_{p_\theta}}{F_{p_a}} = -\frac{-\frac{2(1-\gamma)^2(p^3-q^3)}{q^3p^3}}{-\frac{2(1-\gamma)^2(p^3-q^3)}{q^3p^3} - c_a} = \frac{-2(1-\gamma)^2(p^3-q^3)}{2(1-\gamma)^2(p^3-q^3) + c_a q^3p^3} < 0$$

$$\frac{dp_a}{d\gamma} = -\frac{F_\gamma}{F_{p_a}} = -\frac{-\frac{2(1-\gamma)(p^2-q^2)}{q^2p^2}}{-\frac{2(1-\gamma)^2(p^3-q^3)}{q^3p^3} - c_a} = \frac{-2(1-\gamma)(p^2-q^2)qp}{2(1-\gamma)^2(p^3-q^3) + c_a q^3p^3} < 0$$

$$\frac{dp_a}{dp_m} = -\frac{F_{p_m}}{F_{p_a}} = -\frac{\frac{2(1-\gamma)^2}{p^3}}{-\frac{2(1-\gamma)^2(p^3-q^3)}{q^3p^3} - c_a} = \frac{2(1-\gamma)^2q^3}{2(1-\gamma)^2(p^3-q^3) + c_a q^3p^3} > 0$$

<u>Comparative statics of the analyst's earnings forecast quality Q_a:</u>

$$\frac{dQ_a}{\partial p_\theta} = \frac{\partial Q_a}{\partial p_\theta} + \frac{\partial Q_a}{\partial p_a}\frac{dp_a}{dp_\theta}$$

$$= \frac{1}{(p_\theta + p_a)^2} - \frac{1}{(p_\theta + p_a)^2}\frac{2(1-\gamma)^2(p^3-q^3)}{2(1-\gamma)^2(p^3-q^3) + c_a q^3p^3} > 0.$$

<u>Comparative statics of the manager's earnings report quality Q_m:</u>

$$\frac{dQ_m}{dp_\theta} = \frac{\partial Q_m}{\partial p_\theta} + \frac{\partial Q_m}{\partial p_a}\frac{dp_a}{dp_\theta}$$

$$= \frac{q^2 + \gamma^2(p^2-q^2)}{q^2p^2} + \left(\frac{q^2 + \gamma^2(p^2-q^2)}{q^2p^2}\right)\left(\frac{-2(1-\gamma)^2(p^3-q^3)}{2(1-\gamma)^2(p^3-q^3) + c_a q^3p^3}\right) > 0$$

$$\frac{dQ_m}{d\gamma} = \frac{\partial Q_m}{\partial p_a}\frac{dp_a}{d\gamma} + \frac{\partial Q_m}{\partial \gamma}$$

$$= \left(\frac{q^2 + \gamma^2(p^2 - q^2)}{q^2p^2}\right)\left(\frac{-2(1-\gamma)(p^2 - q^2)qp}{2(1-\gamma)^2(p^3 - q^3) + c_a q^3 p^3}\right) - \frac{2\gamma(p-q)}{qp} < 0$$

$$\frac{dQ_m}{dp_m} = \frac{\partial Q_m}{\partial p_a}\frac{dp_a}{dp_m} + \frac{\partial Q_m}{\partial p_m}$$

$$= \left(\frac{q^2 + \gamma^2(p^2 - q^2)}{q^2p^2}\right)\left(\frac{2(1-\gamma)^2 q^3}{2(1-\gamma)^2(p^3 - q^3) + c_a q^3 p^3}\right) + \frac{1-\gamma^2}{p^2} > 0$$

<u>Comparative statics of the analyst's utility R_a:</u>

$$\frac{dR_a}{dp_\theta} = \frac{\partial R}{\partial p_\theta} + \frac{\partial R_a}{\partial p_a}\frac{dp_a}{dp_\theta}$$

$$= \frac{(1-\gamma)^2(p^2 - q^2)}{p^2q^2} + \left(\frac{(1-\gamma)^2(p^2 - q^2)}{p^2q^2}\right)\left(\frac{-2(1-\gamma)^2(p^3 - q^3)}{2(1-\gamma)^2(p^3 - q^3) + c_a q^3 p^3}\right)$$

$$= \frac{(1-\gamma)^2(p^2 - q^2)c_a qp}{2(1-\gamma)^2(p^3 - q^3) + c_a q^3 p^3} > 0$$

$$\frac{dR_a}{d\gamma} = \frac{\partial R_a}{\partial p_a}\frac{dp_a}{d\gamma} + \frac{\partial R_a}{\partial \gamma}$$

$$= \left(\frac{(1-\gamma)^2(p^2 - q^2)}{p^2q^2}\right)\left(\frac{-2(1-\gamma)(p^2 - q^2)qp}{2(1-\gamma)^2(p^3 - q^3) + c_a q^3 p^3}\right) + \frac{2(1-\gamma)(p-q)}{pq}$$

$$= \frac{-2(1-\gamma)^3(p^2 - q^2)^2 + 2(1-\gamma)(p-q)(2(1-\gamma)^2(p^3 - q^3) + c_a q^3 p^3)}{(2(1-\gamma)^2(p^3 - q^3) + c_a q^3 p^3)qp} > 0$$

For R_a to increase in γ, the numerator must fulfil the following condition:

$-2(1-\gamma)^3(p^2 - q^2)^2 + 2(1-\gamma)(p-q)[2(1-\gamma)^2(p^3 - q^3) + c_a q^3 p^3] > 0$

$\Leftrightarrow -(1-\gamma)^2(p^2 - q^2)^2 + 2(1-\gamma)^2(p^3 - q^3)(p-q) + c_a q^3 p^3 (p-q) > 0$

$\Leftrightarrow (1-\gamma)^2\big(-p^4 + 2p^2q^2 - q^4 + 2(p^4 - p^3q - q^3p + q^4)\big) + c_a q^3 p^3 (p-q) > 0$

$\Leftrightarrow (1-\gamma)^2(p^4 - 2p^3q + 2p^2q^2 - 2q^3p + q^4) + c_a q^3 p^3 (p-q) > 0$

$\Leftrightarrow (1-\gamma)^2(p-q)^2(p^2 + q^2) + c_a q^3 p^3 (p-q) > 0.$

Since the condition above is always fulfilled, the sign of $dR_a/d\gamma$ is necessarily positive.

$$\frac{dR_a}{dp_m} = \frac{\partial R_a}{\partial p_a}\frac{dp_a}{dp_m} + \frac{\partial R_a}{\partial p_m}$$

$$= \left(\frac{(1-\gamma)^2(p^2 - q^2)}{p^2q^2}\right)\left(\frac{2(1-\gamma)^2 q^3}{2(1-\gamma)^2(p^3 - q^3) + c_a q^3 p^3}\right) - \frac{(1-\gamma)^2}{p^2}$$

$$= \frac{(1-\gamma)^2}{p^2}\left(\frac{2(1-\gamma)^2 q(p^2 - q^2) - 2(1-\gamma)^2(p^3 - q^3) - c_a q^3 p^3}{2(1-\gamma)^2(p^3 - q^3) + c_a q^3 p^3}\right) < 0$$

For R_a to decrease in p_m, the following condition must hold:

$$2(1-\gamma)^2 q(p^2-q^2) - 2(1-\gamma)^2(p^3-q^3) - c_a q^3 p^3 < 0$$

$$\Leftrightarrow -2(1-\gamma)^2(p-q)p^2 - c_a q^3 p^3 < 0$$

Since the condition above is always fulfilled, the sign of dR_a/dp_m is necessarily negative.

I. Manager's Expected Utility

In order to compute the manager's expected utility, it helps to first determine some preliminary results. To begin, the term $E\left((\tilde{\theta}-\tilde{r}_m)^2\right)$ is determined:

$$E\left((\tilde{\theta}-\tilde{r}_m)^2\right) = Var(\tilde{\theta}-\tilde{r}_m)$$

$$= Var\left(\tilde{\theta} - \left(\frac{(p_\theta+p_a+\gamma p_m)p_a}{(p_\theta+p_a+p_m)(p_\theta+p_a)}\tilde{s}_a + \frac{(1-\gamma)p_m}{p_\theta+p_a+p_m}\tilde{s}_m\right)\right)$$

$$= Var\begin{pmatrix} \frac{(p_\theta+p_a+p_m)(p_\theta+p_a)}{(p_\theta+p_a+p_m)(p_\theta+p_a)}\tilde{\theta} \\ -\frac{(p_\theta+p_a+\gamma p_m)p_a}{(p_\theta+p_a+p_m)(p_\theta+p_a)}(\tilde{\theta}+\tilde{\varepsilon}_a) \\ -\frac{(1-\gamma)p_m(p_\theta+p_a)}{(p_\theta+p_a+p_m)(p_\theta+p_a)}(\tilde{\theta}+\tilde{\eta}) \end{pmatrix}$$

$$= Var\begin{pmatrix} \frac{(p_\theta+p_a+\gamma p_m)p_\theta}{(p_\theta+p_a+p_m)(p_\theta+p_a)}\tilde{\theta} \\ -\frac{(p_\theta+p_a+\gamma p_m)p_a}{(p_\theta+p_a+p_m)(p_\theta+p_a)}\tilde{\varepsilon}_a \\ -\frac{(1-\gamma)p_m(p_\theta+p_a)}{(p_\theta+p_a+p_m)(p_\theta+p_a)}\tilde{\eta} \end{pmatrix}$$

$$= \frac{(p_\theta+p_a+\gamma p_m)^2 p_\theta + (p_\theta+p_a+\gamma p_m)^2 p_a + (1-\gamma)^2 p_m (p_\theta+p_a)^2}{(p_\theta+p_a+p_m)^2(p_\theta+p_a)^2}$$

$$= \frac{(p_\theta+p_a+\gamma p_m)^2 + (1-\gamma)^2 p_m(p_\theta+p_a)}{(p_\theta+p_a+p_m)^2(p_\theta+p_a)}$$

$$= \frac{(p_\theta+p_a)^2 + 2(p_\theta+p_a)\gamma p_m + \gamma^2 p_m^2 + (1-\gamma)^2 p_m(p_\theta+p_a)}{(p_\theta+p_a+p_m)^2(p_\theta+p_a)}$$

$$= \frac{(p_\theta+p_a)(p_\theta+p_a+2\gamma p_m+p_m-2\gamma p_m+\gamma^2 p_m)+\gamma^2 p_m^2}{(p_\theta+p_a+p_m)^2(p_\theta+p_a)}$$

$$= \frac{(p_\theta + p_a)(p_\theta + p_a + p_m + \gamma^2 p_m) + \gamma^2 p_m^2}{(p_\theta + p_a + p_m)^2 (p_\theta + p_a)}$$

$$= \frac{(p_\theta + p_a)(p_\theta + p_a + p_m) + \gamma^2 p_m (p_\theta + p_a) + \gamma^2 p_m^2}{(p_\theta + p_a + p_m)^2 (p_\theta + p_a)}$$

$$= \frac{(p_\theta + p_a)(p_\theta + p_a + p_m) + \gamma^2 p_m (p_\theta + p_a + p_m)}{(p_\theta + p_a + p_m)^2 (p_\theta + p_a)}$$

$$= \frac{(p_\theta + p_a + p_m)(p_\theta + p_a + p_m \gamma^2)}{(p_\theta + p_a + p_m)^2 (p_\theta + p_a)}$$

$$= \frac{p_\theta + p_a + p_m \gamma^2}{(p_\theta + p_a + p_m)(p_\theta + p_a)}.$$

Next, recall that $E(-(\tilde{r}_a - \tilde{r}_m)^2)$ was calculated earlier in appendix G:

$$E(-(\tilde{r}_a - \tilde{r}_m)^2) = -E((\tilde{r}_a - \tilde{r}_m)^2) = -Var(\tilde{r}_a - \tilde{r}_m) = -\frac{(1-\gamma)^2 p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)}.$$

Simplifying the manager's expected utility leads to the following result:

$$E(\tilde{U}_m) = E\left(-(1-\gamma)\left(\tilde{\theta} - \tilde{r}_m\right)^2 - \gamma(\tilde{r}_a - \tilde{r}_m)^2\right)$$

$$= -(1-\gamma)\, E\left(\left(\tilde{\theta} - \tilde{r}_m\right)^2\right) - \gamma\, E((\tilde{r}_a - \tilde{r}_m)^2)$$

Now, $E\left(\left(\tilde{\theta} - \tilde{r}_m\right)^2\right)$ and $E((\tilde{r}_a - \tilde{r}_m)^2)$ from above can be substituted into the equation above which yields

$$= -(1-\gamma)\frac{p_\theta + p_a + p_m \gamma^2}{(p_\theta + p_a + p_m)(p_\theta + p_a)} - \frac{\gamma(1-\gamma)^2 p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)}$$

$$= -(1-\gamma)\frac{p_\theta + p_a + \gamma p_m}{(p_\theta + p_a + p_m)(p_\theta + p_a)}.$$

J. Comparative statics for Section 4.2.3

The comparative static results of section 4.2.3 are derived and summarised below. Recall that for brevity of notation $v \equiv p_\theta + p_b + p_m$, and $w \equiv p_\theta + p_b$.

<u>Required partial derivatives:</u>

The partial derivatives of $F(p_\theta, p_b, c_b)$, which is given by the left-hand side of (4.80) are

$$F_{c_b} = -p_b,$$
$$F_{p_b} = \frac{-2}{(p_\theta + p_b)^3} - c_b, \text{and}$$
$$F_{p_\theta} = \frac{-2}{(p_\theta + p_b)^3}.$$

<u>Comparative statics of the precision p_b:</u>

$$\frac{dp_b}{dc_b} = -\frac{F_{c_b}}{F_{p_b}} = \frac{-p_b(p_\theta + p_b)^3}{2 + (p_\theta + p_b)^3 c_b} < 0$$

$$\frac{dp_b}{dp_\theta} = -\frac{F_{p_\theta}}{F_{p_b}} = \frac{-2}{2 + (p_\theta + p_b)^3 c_b} < 0$$

<u>Comparative statics of the analyst's expected utility R_b and his forecast quality Q_b:</u>

$$\frac{dR_b}{dp_\theta} = \frac{\partial R_b}{\partial p_\theta} + \frac{\partial R_b}{\partial p_b}\frac{dp_b}{dp_\theta} = \frac{1}{(p_\theta + p_b)^2}\left(\frac{(p_\theta + p_b)^3 c_b}{2 + (p_\theta + p_b)^3 c_b}\right) > 0$$

<u>Comparative statics of the manager's earnings report quality Q_m:</u>

$$\frac{dQ_m}{dp_\theta} = \frac{\partial Q_m}{\partial p_\theta} + \frac{\partial Q_m}{\partial p_b}\frac{dp_b}{dp_\theta} = \frac{w^2 + \gamma^2(v^2 - w^2)}{v^2}\left(\frac{w c_b}{2 + w^3 c_b}\right) > 0$$

7 References

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