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Investment Decisions and Effort Incentives in the Presence of Uncertain Ability

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For my father

Contents

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Glossary

$C(e_t)$	Convex effort cost function , 72
H_t	History of the game up to period t , 73
M_{new}	Newly hired manager who takes over business from a preceding manager , 39
M_{pre}	Manager who just left the company, predecessor to M_{new} and initiator of the ongoing project , 39
O	Owner of the company (*she*) , 39
P	Ongoing strategic investment project initiated by the preceding manager M_{pre} , 41
U	Overall utility of the agent in chapter 4 , 72
W_t	Wage of the agent in period t , 72
$X_{i,t}$	Disaggregate performance measures , 89
Y_t	Performance measure for the output of the agents work in period t , 72
Π_H	High output of the agents work in chapter 4 , 72
η	Ex ante probability that the manager is of high ability , 40
$\iota(P)$	Initiator of the project P , 41
κ_t	Level of confidence in period t , 77
$\hat{\eta}_t$	Probability that the agent is of high ability at the end of period t , 73
$\hat{a}_0$	Common prior belief of the manager and the owner; also referred to as $\hat{a}$, 73
$\hat{a}_t$	Updated belief about the managers ability at the end of period t , 73
$\hat{a}_t^b$	Biased self-assessment of the agent on his ability , 83
$\hat{a}_{pre}$	Reputation of the Manager M_{pre} who just left the company , 39

$\tilde{P}$	Project that replaces P if the manager decides to divest , 41
ω_P	The new managers utility in case of a successful strategic project , 43
ω_R	A constant, measuring the importance of reputation for the manager , 43
π_M	Overall utility of the manager in chapter 3 , 43
π_O	Overall utility of the owner at the end of the game in chapter 3 , 44
π_{inv}	Managers utility because of the projects success in chapter 3 , 43
π_{op}	Operational payoff at time $t = 2$ in chapter 3. , 42
π_{rep}	Utility from reputation for the manager in chapter 4 , 43
σ	Quality of the signal s, i.e., probability that the signal indicates the right profitability , 41
σ_t	Vector of performance measures Y_i observed in the game up to period t , 78
a	Ability of the manager. Can be either high, i.e. a_H, or low, i.e. a_L , 39
a_H	Ability of a manager of high ability , 72
a_L	Ability of a manager of high ability , 72
c	Constant reflecting the agents individual level of effort cost , 72
e_t	Level of effort the agent exerts in period t , 72
e_t^*	Optimal effort level in period t for a rational agent , 76
e_t^{*b}	Optimal effort level in period t for a biased agent , 76
n	Number of periods in chapter 4 , 72
s	Signal indicating the profitability of the project P , 41
t	Index of the current period , 72

CHAPTER 1

Introduction

In modern corporations shareholders delegate managerial decision making to hired managers.[1] A manager's success in leading a company strongly depends on his ability. The importance of managerial ability is, for example, reflected in stock market behavior. The market seems to value companies higher, which are led by managers with a reputation of high ability. A good recent example to demonstrate this is the case of US computer and entertainment products producer Apple. In late 2008 and early 2009, there were large levels of uncertainty about the health of Apple CEO Steve Jobs. False rumors about a possible severe illness made the stock price of Apple temporarily drop almost 10%.[2] Jobs had a very high market reputation of being a good manager for Apple and the uncertainty about his health put this at stake. This indicates that the market seems to see a close linkage between management ability and the future performance of the company.

But not only the influence of a good market reputation underlines the link between ability and performance. On the contrary, a manager of high ability has a higher productivity level, leading to a higher expected output level. Therefore, a manager's self perception of his ability determines his own expected level of productivity. The higher he thinks of his ability, the more is he willing to exert effort for the benefit of the company.[3] Hence, not only the market but also his own

[1]For an overview about the problem of delegation and the comparison with central decision making see Holmström (1984); Melumad and Reichelstein (1987), p.1; Melumad et al. (1995), pp. 654-656; Itoh (2001), pp. 1-2; Sliwka (2001) A more detailed introduction to this setting is given in chapter 2.

[2]Apple's stock dropped 10% within 10 minutes on Oct. 3, 2008, see, e.g., CNN-Money (2008).

[3]See chapter 2 for a more detailed survey.

perception of his ability determine the manager's behavior and with it the potential performance of the company.

Ability, however, is not a directly measurable or clearly observable metric. Usually, its assessment is affected by a high level of uncertainty. Uncertainty can exist both on the side of the external market, i.e. his market reputation, and on the side of the manager himself, i.e. his self-assessment. Since the manager's ability is a very important determinant for his effort and investment decisions, these two aspects of uncertainty should have a significant influence on his incentives and, therefore, his behavior.

A large stream in accounting literature addresses the question, how to provide the right incentives for a manager such that his objectives are aligned with that of the shareholders and that he exerts optimal levels of effort in their best interest. This is done by designing performance measures for value creation and linking these to management compensation in a compensation contract.[4] Early theoretical approaches that investigated managerial behavior in a setting of delegation with information asymmetry – called an agency or principal-agent setting[5] – assumed players to be purely rational.[6] It was their sole concern to maximize their own wealth. Their utility was only determined by a (monetary) wage and costs they bore for the effort they exerted.

Later, these approaches were extended to capture further features of human behavior.[7] The picture of purely rational individuals was

[4]See Holmström (1979) for first considerations of moral hazard; Spremann (1987); Holmström and Milgrom (1987) for a simplification with linear compensation contracts (LEN); and Reichelstein (1997) and Rogerson (1997) on goal congruent performance measures for investment decisions.

[5]These terms were originally introduced by Ross (1973) and Jensen and Meckling (1976).

[6]Commonly referred to as *homo oeconomicus*. See Mill (1874).

[7]Especially in finance, behavioral aspects have been frequently analyzed. See Subrahmanyam (2008) for a recent overview of behavioral finance.

refined by introducing aspects from behavioral psychology (e.g., conservatism, herd behavior, etc.) and including non-financial factors (e.g., utility because of envy, greed or career concerns) into the manager's objective function. The goal of this work is to analyze how uncertainty about a manager's ability from both a market reputation and a self-assessment perspective changes classical results on a manager's investment decisions and effort incentives. We will see that the assessment of a manager's ability is an important determinant for his behavior.

On the one hand, we want to show how a manager who has a strong interest in his reputation takes different investment decisions than those predicted by theoretical models that neglect this common human feature. In particular, a manager may take investment decisions that are not in the company's best interest solely to improve his own reputation. In a model of career concerns, we find a rationale behind existing empirical results that manager's tend to reverse investment decisions of their predecessors.[8]

On the other hand, we will investigate the influence a manager's self-assessment of his ability has on the decision how much effort to exert when working for a company that is not his own. We will look at situations where this self-assessment is not fully rational and see how a behavioral bias changes a manager's effort level. Most fundamentally, we can show that existing results on effort incentives are strongly dependent on the manager's own assessment of his ability. We find this by analyzing the influence of self-attribution bias on a manager's effort incentives. Self-attribution bias is a common human feature that determines how a person assesses his own ability. It states that individuals tend to take too much credit for positive outcomes of their work while attributing negative outcomes to external factors such as bad luck.

[8]See, e.g., Weisbach (1995).

Despite the strong evidence of this bias as part of human behavior[9] existing accounting literature analyzing a managers effort incentives has mostly neglected this bias so far.[10] Hence, our work contributes to the existing literature by systematically examining the influence of ability assessment as a determinant for creating investment and effort incentives. All of the analyses done in our work are based on principal-agent models, which we extend to capture the influence of market reputation and self-assessment of ability.

The remainder of this work is structured as follows. We start our analysis, in chapter 2, with an introduction to the challenges arising from managerial delegation in order to systematically derive the central topic of this work. We find that delegation in combination with information asymmetry and conflict of interest between the owner and the manager of a company leads to two problems for the owner: an incentive and a selection problem. After that, we show how approaches in the existing theoretical literature try to address these problems using two classes of principal-agent models. Finally, we discuss the importance of ability as one of the key determinants for a manager's incentives. Since there is usually a high level of uncertainty when assessing ability, this uncertainty should be considered when analyzing a manager's investment decisions and effort incentives. We use this argument to motivate our later analyses on the influences of reputation (market uncertainty) and self-attribution bias (uncertainty in self-assessement).

The importance of external ability assessment by the market, i.e. a manager's market reputation, is the central subject matter in chapter 3. We look at a situation of recent executive turnover, in which a newly hired manager has to decide on the future of an investment project

[9]See Hastorf, Schneider and Polefka (1970); Wolosin, Sherman and Till (1973); Langer and Roth (1975); Miller and Ross (1975) for evidence on self-attribution bias.

[10]In behavioral finance, on the contrary, a growing stream of research has analyzed this and other biases. For a brief overview on this literature and existing approaches in accounting, see chapter 4.

taken over by his predecessor. Based on a signal about the project's expected profitability, he has to decide whether to keep the project or cancel it in oder to replace it with a new one of his own. The manager is concerned with his future career and, hence, interested in his market reputation in the sense that his utility function not only depends on his (monetary) wage but also his reputation. We analyze the effects of career concerns on the manager's divest/invest decision depending on his ability and discuss the consequences for the traditional literature on investment incentives and the hiring process. Furthermore, we try to shed some light on possible mechanisms explaining the relationship between pre- and post-turnover company performance.

In chapter 4, we investigate the effects of self-attribution bias on managerial behavior in a multi-period moral hazard setting with linear compensation schemes. The manager does not know his own ability[11] but learns it by observing the outcome of his work. Due to the bias, his learning is not rational from the point of view of a rational principal. We will compare this manager's behavior and choice of effort level to that of a purely rational one and draw conclusions how the bias alters the choice of the right performance measures for that manager to create effort incentives. In particular, will we see how this changes the optimal level of information detail for different bias and experience levels.

Finally, chapter 5 concludes by summing up the results of the previous analyses and commenting on their contribution to the existing literature. We discuss the boundaries and limitations of the models and its assumptions and provide some thoughts on possible extensions of these models and further research. Proofs for the theoretical results can be found in the appendix.

[11]This is particularly reasonable for inexperienced managers, who take their first management assignment.

CHAPTER 2

Background on Managerial Incentives in the Context of Delegation and Uncertain Ability

In this chapter we systematically derive the central topic of this work, i.e., the challenges of creating the right managerial investment and effort incentives, as a consequence of delegation. We find that due to the separation of ownership and control hired manager's may not always behave in the company's best interest. Thus, the owner of the company has to actively create incentives for the manager such that their interests are aligned. Furthermore, he has an interest to select and hire the best manager available to work on his behalf. After classifying these fundamental challenges, we give an introduction on the principal-agent framework as one of the most important theoretical instruments to analyze these. After a general introduction to this framework, we briefly discuss specific existing approaches for the incentive and selection problems. Finally, we show that ability is an important determinant for analyzing a manager's incentives. It is, however, also a feature involving a high level of uncertainty. This uncertainty when assessing ability consists of two sides: uncertainty on the market side and on the side of the manager himself. To analyze the effects of both sides of uncertainty, we introduce and classify possible extensions we will use in our analyses of the effects of uncertain ability in the upcoming chapters.

2.1. Challenges Arising from Managerial Delegation

2.1.1. The Separation of Ownership and Control. Unlike in former times, when businesses were mostly family owned and decisions where mainly made by the company owner, in modern corporations external managers are hired to handle business on the shareholders' behalf.[1] Not a single owner, but usually a larger group of minority shareholders[2] takes the position of the residual claimant and with it the financial risk. These shareholders do not actively participate in management decisions but delegate[3] those to hired managers.

From an owner's perspective, there are various reasons for this form of delegation:[4] Most importantly, shareholders try to diversify their risks by investing in a portfolio of firms. As a consequence, they usually only have little shares of many companies. The importance of a single investor is rather small. Therefore, a prevalent argument for delegation is that due to limitations of time and information-processing capabilities[5] owners cannot take all the decisions for their companies. They have to *delegate*.[6]

Despite this necessity for delegation, owners may also benefit from it. Hired managers may bring specific expertise necessary for their position.[7] Expertise, shareholders usually lack.[8] Or they may have superior private information, e.g. about the profitability of certain investment decisions or the chances in a specific product market[9] that makes delegation to the manager favorable.[10] Finally, in a dynamic

[1]See Smith (1776) and Berle and Means (1932) and Berle (1959) for early disquisitions on the separation of ownership and control.

[2]We will use the terms owners and shareholders interchangeably in this chapter, knowing that most equity holders only posses small shares in a company.

[3]Situations of delegation not only arise between owners and managers, but are also essential for the relationship between central and divisional management. See Milgrom and Roberts (1992) for an example.

[4]See Kräkel (2004) for an overview.

[5]See Williamson (1975); Williamson (1985) and Melumad, Mookherjee and Reichelstein(1995) for studies on the importance of limited information-processing capabilities for hierarchical organizations.

[6]See Melumad and Reichelstein (1987), p.1.

[7]Itoh (2001) calls this technological advantage.

[8]See Fama(1980); Fama and Jensen (1983).

[9]See Milgrom and Roberts (1992), pp. 544-545.

[10]Another approach to benefit from a manager's private information is to create incentives for him to report these to the owner. Under specific assumptions, truthful reporting can be achieved. Myerson (1979) established a theoretical basis for truthful reporting referred to as the revelation principle. See Mas-Colell et al. (1995), p. 493, for a more recent introduction to the revelation principle.

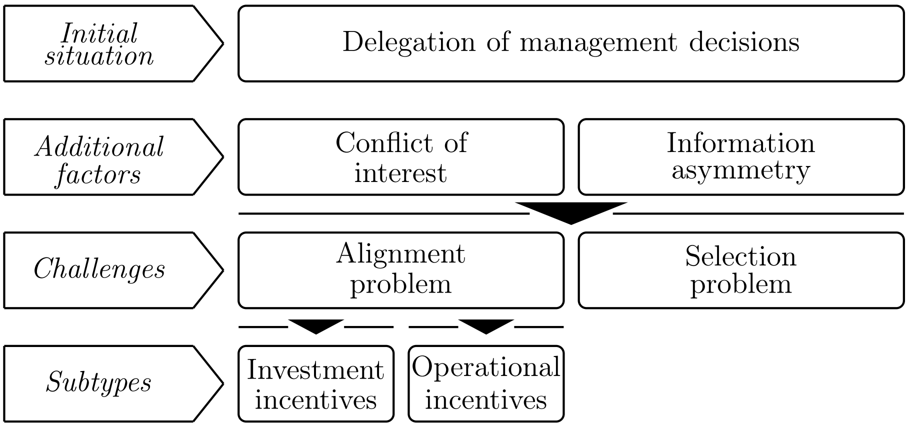

FIGURE 1. Challenges of delegation, information asymmetry and conflict of interest.

setting, another benefit of delegation is that it helps the owner to assess the manager's ability.[11] This last point particularly important for our model: in chapter 4 we will consider a model in which both manager and owner do not know the manager's ability but learn it by observing the outcome of his work. We will see that learning is an important part in understanding effort incentives of the manager.

2.1.2. A Classification of the Challenges Due to Managerial Delegation. But there are also challenges arising from delegation, despite the advantages. Delegation on its own does not lead to problems for the shareholders. Two additional factors that usually occur in combination with delegation, however, do create certain challenges: conflict of interest and information asymmetry. First of all, the objectives of the manager may differ significantly from those of the shareholders.[12] While the shareholder is primarily interested in firm value creation,[13] the manager will rather optimize his own utility. This may

[11]See Sliwka (2001) for a more detailed explanation.
[12]Shleifer and Vishny (1997), pp. 742-744; Tirole (2001), pp. 1-2; and Kräkel (2004), pp. 273-280 give an overview of possible misalignments.
[13]See Young and O'Byrne (2000), pp. 3-19, for reasons as why to pursue a shareholder value approach.

give rise to a conflict of interest between these two parties.[14]

The manager's utility may differ from that of the owner in various ways. For example, due to reasons of reputation, a manager may prefer being in charge of a large corporation to a smaller company. Thus, he puts too much emphasis on mere company size – a phenomenon commonly described as empire building.[15] Additionally, he may have a tendency towards unnecessary corporate acquisitions for his personal profit, like an expensive business car, office furniture or extended business trips. Finally, his time horizon[16] may differ from that of the more long-term oriented shareholders. As a result, this may induce a preference for short-term earnings and suboptimal investment levels.

A second factor potentially creating managerial challenges in situations of delegation is information asymmetry.[17] The fact that the manager possesses superior information can be beneficial for the company and is one of the reasons for delegation. It may, however, also encourage him to behave in an opportunistic manner. A manager's private information – like his ability or information about his productivity – may be very valuable to the company, but might not always be used in the owner's best interest.

These two factors – conflict of interest and information asymmetry – lead to two corresponding challenges for the shareholders: an alignment and a selection problem. Due to the conflict of interest, the shareholder has to align his and the manager's objectives. As we will

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[14] This conflict of interest has been subject to a broad band of research. See for example Reichelstein (1997) for a discussion on goal congruence.

[15] See Baumol (1959); Williamson (1963) and (1964) for early analyses of empire building and Baldenius (2003) for a recent one.

[16] The impatience of managers has been analyzed in a large body of research. This includes Holmström (1989); Laux (1999); Pfeiffer (2003); Dutta and Reichelstein (2005a) and Friedl (2005).

[17] In section 2.2, we will distinguish types of information asymmetry in further detail.

see in the next section, a common approach for this is to create incentives using compensation contracts that let the manager participate in the shareholders' success. The alignment problem can be further distinguished depending on the type of incentives needed. There are those related to investment decisions and those related to operational decisions:[18] On the one hand, the shareholders want the manager to invest their money only in projects that create value for them. On the other hand, they want him to work hard and pursue activities enhancing revenue or reducing costs[19]. In reality, a combination of both of these problems very often occurs.[20]

The second problem, the shareholders face, occurs one step before the alignment problem. It can be described as a selection problem.[21] Not only do shareholders want the manager to behave in their best interest, they also want to delegate decision making to the most capable manager available for the job.[22] This challenge does not only arise for the shareholder in the hiring process, but is a recurring problem in their relationship.[23] The manager may have incentives to work under false pretense and overstate his own abilities. The abilities of the manager, however, are crucial for his productivity. Therefore, assessing ability and selecting a good manager may have a large impact on the performance of the company.

[18]See Friedl (2006) for details on the following thoughts.

[19]In chapter 3 we will see a model of career concerns, which combines both types of incentives.

[20]Recent studies have, therefore, combined these two settings. See, e.g. Dutta and Reichelstein (2002).

[21]Early approaches of solving the selection problem by assessing a job candidate's specific ability go back to the 1970s. See Laux (1972); Laux (1979), pp. 69-247; Laux and Liermann (1997), pp. 218-233; and Kräkel (2004, pp. 119-121.

[22]Either given that there is more than one candidate, or that it takes a minimum level of qualification to perform well.

[23]A shareholder may be fired, or existing contracts may not be renewed. See chapter 3 for one example analysis concerning the hiring/firing decision.

Figure 1 summarizes the challenges of delegation we just discussed. In this work, we will examine both kinds of problems in two principal-agent models. Chapter 3 analyzes a combination of these two problems. We will consider both a manager's incentives in an investment decision and the owner's hiring decision when ability is uncertain and reputation concerns are involved.[24] The model in chapter 4 focuses on an incentive problem. We will examine how a manager's effort decisions strongly depend on the agent's learning about his ability and how the owner should adjust incentives to incorporate these aspects.

2.2. Existing Approaches for the Incentive and Selection Problem in the Theoretical Literature

2.2.1. The Principal-Agent Framework as a General Approach. Managerial delegation in combination with information asymmetry and conflict of interest (between management and shareholders) can create incentive and selection problems. In the existing literature, one framework of growing importance to analyze these problems is that of agency theory.[25] In this section, we will give a short introduction to this framework, as it is the basis used for the analyses in the remainder of this work.

One person – the principal – engages another person – the agent – to perform some service on his behalf, which involves delegating decision making authority to the agent.[26] Thus, the delegation setting of an owner and a manager, we have looked at so far, can be described as an agency.[27]

The relationship between principal and agent is closely linked to the kind of information asymmetry that exists between these two parties. Most authors distinguish between two different forms of information

[24]See the next section 2.2 for a more detailed classification of this work with respect to existing approaches.

[25]See Elschen (1991), p. 1004 or Milgrom and Roberts (1992), pp. 166-168.

[26]See Jensen and Meckling (1976), p. 308.

[27]For an overview of other possible agency relationships see, e.g., Jost (2001a).

asymmetry: Hidden action and hidden information.[28] Hidden information describes a situation, in which one of the two parties has some private information.[29] Hidden action, on the other hand, means that one of the two may perform an unobservable action. Agency theory models classically distinguish between two basic problems. The first, moral hazard, describes the problem of post-contract opportunistic behavior, as a result of unobservable action(s).[30] The second, adverse selection,[31] on the contrary, analyzes situations of pre-contract private information.[32] In both settings, the two parties try to maximize their utility: The principal wants to maximize the agent's effort and minimize the information rent he has to pay the agent due to his private information. These two types of principal-agent models – moral hazard and adverse selection – each address aspects of one of the two challenges – the incentive and selection problem – we identified in the previous section. In reality, both forms of information asymmetry can occur at the same time. Therefore, theoretic models are often a mixture of the two basic model types.[33] In addition, other forms of game theory models with two or more players exist. Since these are of less importance for our analyses, we skip their discussion.[34]

[28]In some parts of the literature, two additional types of information asymmetry – hidden characteristics and hidden intention – are discussed. Most authors however treat these as subtypes of the ones given here. See Arrow (1985), p. 38.

[29]Usually the party, which possesses private information is the agent.

[30]At the time of contracting, no information asymmetry exists.

[31]One of the first settings of adverse selection was the famous one described by Akerlof (1970) for dealers and sellers of used cars.

[32]There is no consistent use of the four terms hidden information, hidden action, moral hazard and adverse selection in the literature. Some authors use "moral hazard" as synonym for "hidden action" and "adverse selection" as synonym for "hidden information". Some use hidden information and hidden action as purely post-contractual and call pre-contractual asymmetry "hidden characteristics". See Kräkel (2004), p. 23. for a discussion of this topic.

[33]For example, in many moral hazard models with unobservable effort decision, the agent is assumed to have superior information about his ability, an investment decision or other measures of productivity.

[34]For a review of some models and their usage to analyze problems of business administration, see, e.g., Jost (2001b).

In the next two subsections of this chapter, we will present specific existing approaches that address the incentive and the selection problem. In all of the upcoming discussions, we will always try to link the these problems to specific existing model framework of principal-agent theory.

2.2.2. Specific Approaches for the Incentive Problem.

2.2.2.1. *The Two Determinants of a Compensation Contract.* Our discussion starts with the incentive problem. In order to align the owner's interests with those of the manager and create the right incentives, existing literature investigates the use of compensation contracts.[35] Through a contract, the owner tries to let the manager participate in the creation of shareholder value, while minimizing total compensation costs.[36] Using such a contract to align interests bears two basic problems: i) the basic structure of the contract and ii) the measures used as basis for performance assessment.

The first problem focuses on the efficient distribution between the two opposing goals of creating incentives and sharing risks.[37] A stronger linkage between company performance and management compensation creates stronger incentives for the manager. At the same time, however, it transfers risk from the owner to the manager. The goal of an optimal compensation contract is to give a solution to this trade-off. If the manager is risk averse, there is an optimal level at which the positive effects due to the additional incentives and the negative effects from additional risk are in balance. This question of designing the optimal contract structure can be addressed in a classical principal-agent setting.[38]

[35]See Laffont and Martimort (2001) or Bolton and Dewatripont (2005) for a comprehensive introduction to incentive and contract theory.
[36]Or in other words, maximize the owner's overall utility.
[37]See Laux and Liermann (1997).
[38]Also called agency setting. See Ross (1973) or Jensen and Meckling (1976).

The second problem deals with the question, which metrics to use in a compensation contract. The question here is, how different measures capture firm value creation. In practice, such contracts are usually either based on a performance measure of the company's market value – using firm stock or stock options – or on some earnings or profitability accrual. We will have a closer look at existing theoretical solutions to these two basic problems of contract design.

2.2.2.2. *The Structure of Compensation Contracts.* Relationships between the owner and the manager of a company are usually built on some form of contract. This contract defines the agent's compensation for his work as a function of a performance measure. A simple form of compensation would be a fixed pay. Such a contract would leave all the risk of company performance with the principal and would create no incentive for the manager to perform well. The compensation would be constant and independent of the manager's performance.

Besides this simple constant form, the compensation function could be linear, convex, concave or a mixture of any of the afore mentioned.[39] In the linear case, an increase or decrease in the performance measure would result in an analogous increase or decrease in the management compensation – weighted with some constant $c \leq 1$. Specific for such a contract is the fact that compensation has neither an upper nor lower bound. The agent's compensation can even become negative.[40] This form of contract therefore represents one extreme in the sense that it creates strong incentives but also transfers a large level of risk.

In practice, compensation usually has an upper or lower cap.[41] It normally neither goes below a positive fixed value nor exceeds some maximum.[42] Compensation that only has a lower bound is represented

[39]See, e.g., Murphy (1999), p. 2505. Contracts may not always be continuous but could involve discrete payments, e.g. when a certain performance level is reached.
[40]This is often referred to as punishment.
[41]See Murphy (1999), p. 2499. for a review of bonus contracts in the US.
[42]This form of compensation is both (locally) convex and concave.

by a convex compensation function. A contract containing stock options is an example of such a convex function, as its lower bound is 0 and it does not have an upper bound.[43]

In the theoretical literature, one approach to determine the optimal contract structure is to use a moral hazard agency model.[44] The general moral hazard model goes back to Holmström (1979).[45] It considers a single period situation, in which the principle offers a compensation contract to the agent that depends on the agent's output. It's aim is to describe a contract that creates the optimal utility from the principal's point of view.

This general moral hazard setting, however, can only be solved under very specific conditions.[46] Recent research has, therefore, used simplifications of the general moral hazard model with additional assumptions. A well solvable restricted version we will also use as a basis for our analysis in chapter 4 is the LEN-framework, going back to Spremann (1987) and Holmström and Milgrom (1987). It is based on three basic assumptions:[47]

- **L**inearity: The model only considers linear compensation contracts,
- **E**xponential utility: Both principal and agent have an exponential utility function, and
- **N**ormally distributed noise/risk term.

Recent research has extended this basic settings in many directions. Some papers use multiple agents to model different hierarchy levels of

[43]See Friedl (2006), p.29.
[44]A different approach to create incentives is addressed in models of tournaments. See, e.g., Lazear and Rosen (1981).
[45]See Gibbons (2005) for a review on the development of this model in recent years.
[46]See Rogerson (1985); Laux (1990); Mirrlees (1999) and Friedl (2006).
[47]See Kräkel (2004), pp. 36-45 for a brief summary on the results of the LEN model.

an organization[48] or employ more than one action[49] to model multitasking.

Most important for our work, however, are dynamic extensions with multiple periods[50]. In this setting, both principal and agent adjust their beliefs as new information becomes available: they learn[51]. This learning changes their behavior. When deciding which action to take, now, a manager has to consider the effects of his decision for the future, i.e. they have to cope with the consequences of their actions. Moreover, due to learning, the overall information quality manager and owner have about important determinants, like their ability, productivity or the economy, rises and with it, potentially, the quality of their decisions. In many situations, learning, therefore, changes the behavior of a manager. In these settings, dynamic multi-period models that consider learning can lead to significantly different predictions on a manager's behavior than static models.

Our analysis in chapter 4 provides one example, where a manager's learning has a strong influence on his effort incentives. The analysis incorporates a dynamic LEN model, in which a manager does not learn rationally, but with a self-attribution bias. As a result, the manager tends to become overconfident and exert more effort than a manager, who learns fully rational.[52] Using more complex models, and including further characteristics of human behavior can, thus, lead to possibly more accurate and realistic predictions.[53]

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[48]See, e.g. Tirole (1986) and (1992).

[49]See Holmström and Milgrom (1991); Feltham and Xie (1994) or Dewatripont, Jewitt and Tirole (2000) for multi action examples.

[50]See, e.g. Rogerson (1985) or Fudenberg, Holmström and Milgrom (1990).

[51]See Fudenberg and Tirole (1983) and Spence (1981) for early dynamic models with focus on learning.

[52]For a more detailed description on self-attribution bias see chapter 4.

[53]The quality of the prediction of theoretical models does not always grow with complexity. Sometimes simpler models may be more suitable to isolate very subtle effects.

2.2.2.3. *The Choice of Performance Measures.* The second part of designing a compensation contract is concerned with the choice of a performance metric. The owner wants to choose performance measures that capture the manager's individual performance in terms of creating value for his company. In practice, usually two general types of performance measures are used: market based measures, which are related to the company's stock price, and accounting based metrics, like earnings or sales. According to an early theoretical result of Holmström (1979), every performance measure that gives additional information about an agent's action, should be included into the compensation contract.[54] In practice, compensation contracts usually try to consider many different dimensions of a manager's performance. The concept of the balanced scorecard is one popular approach[55] that systematically tries to incorporate different dimensions of performance. Due to the importance in the recent scientific and practical discussion on the choice of performance measures, we give a brief introduction on literature about residual income as a performance measure. After that, we look at a stream of literature that is closely related to our analysis in chapter 4 on the optimal level of detail for performance measures.

First, a large body of literature exists that analyzes creating incentives for investment decisions using the residual income[56] as a performance measure.[57] The goal of this was to analyze under which circumstance a linear compensation contract based on accruals could create (strong) goal congruence[58] for an investment decision. Goal congruence means that the goals of the manager and the owner are aligned in the sense that the manager only invests in projects that the owner would choose himself. Regular earnings do not fulfill this, as they do not take

[54]This result is referred to as the *informativeness principle*.

[55]See, e.g., Küpper (2008), pp. 416-423, for an overview on the balanced scorecard.

[56]The most famous residual income measure is the EVA developed by Stern Stewart. See Stern (2001) and Stewart (1991).

[57]The existing literature goes back to the two papers of Rogerson (1997) and Reichstein (1997).

[58]For an overview of the different types of goal congruence see Mohnen and Bareket (2007).

into account the full cost of capital. The manager tends to overinvest. In addition, if the manager has a different time horizon than the owner, he may tend to prefer projects with early returns even when these are not profitable. Reichelstein (1997) showed that residual income[59] is the only performance measure that can achieve strong goal congruence in the context of linear compensation contracts. In the years since these first results were pubished, a large number of papers have used this framework, extended it, and transferred it to related topics.[60]

Secondly, some more recent analyses question the general benefit of using all available performance information in its lowest level of aggregation. These papers mainly use the two points of a) information overload and b) career concerns to justify the usage of less performance information. The literature on information overload states that the quality of managerial decisions only increases with the level of information up to a certain level. Beyond that, it does not increase anymore or may even decrease.[61] On the other hand, recent research showed that due to career concerns of a manager, it may be better from the owner's perspective to use more aggregate performance measures in order to create effort incentives for the manager. More aggregate performance measures provide less performance information, and have, thus, a smaller effect on reputation. Therefore, using more aggregate performance information, may alleviate negative effects of career concerns on the manager's incentives.[62] The new and at first counterintuitive idea this stream of literature introduced was that less and more aggregate performance measures may be better than the highest level

[59]Based on a specific pattern of depreciation.

[60]See, e.g. Dutta and Reichelstein (1999); Pfeiffer (2000); Reichelstein (2000); Dutta and Reichelstein (2002); Baldenius (2003); Wagenhofer (2003), Dutta and Reichelstein (2005a) and (2005b); Baldenius and Reichelstein (2005); Friedl (2006) and (2007) and Rogerson (2008).

[61]See Eppler and Mengis (2004) for a review on the literature of information overload.

[62]For a detailed description and a model on career concerns see chapter 3. See Dewatripont, Jewitt and Tirole (1999) and Arya and Mittendorf (2008) for recent studies on the link between career concerns and the choice of performance measures.

of detail. Our analysis in chapter 4 contributes to this literature by providing a third reason, self-attribution bias, to support this finding. At this point we skip the details, in favor of a thorough discussion in chapter 4.

2.2.3. Specific Approaches for the Selection Problem. The selection problem is a direct result of (pre-contractual) information asymmetry. The better informed manager works for an owner. A common example for information asymmetry in this context is that the manager has superior productivity information, such as his own ability. A situation like this, in which one party's private information has an influence on the outcome of the other party and may potentially be used to harm the other party is called adverse selection.[63] Since the outcomes of managers with different ability may differ significantly, it is in the owner's best interest to determine which managers are good and which are not. On the other hand, good managers want to differentiate from bad managers to benefit from their higher ability. An unfavorable result for the manager would that of adverse selection.

Therefore, these two groups – owners and good managers – have an interest to resolve, or at least reduce, information asymmetry. Both parties can take means to do so. In this setting, actions the better informed manager takes to reduce information asymmetry are called *signaling*.[64] A widespread example is that of providing job references from former employments or certificates for certain skills. On the other hand, actions the manager takes are summarized by the term of screening.[65] The owner may, for example, establish employee feedback of the manager's subordinates or introduce some other form of monitoring.

[63]See Mas-Colell and Whinston and Green (1995), p. 436.
[64]See Spence (1973) and (1974) for early results on signaling.
[65]See Rothschild and Stiglitz (1976) for an analysis on screening. See Kräkel (2004), p. 28; Riley (2001) for a more details to signaling an screening.

The corresponding adverse selection games are, therefore, called signaling and screening games.

Using signaling or screening means, the information asymmetry may be resolved. This is the case, if managers of different types can be distinguished due to their behavior, i.e. if a separating equilibrium exists. In case the two types cannot be distinguished, we speak of a pooling equilibrium, as managers of different types are summarized in the same pool.[66] In chapter 3 we will analyze an adverse selection model where both pooling and separating equilibria exist.[67]

2.3. Uncertain Ability as Determinant for Managerial Incentives

2.3.1. The Influence of Uncertain Managerial Ability on Investment and Effort Incentives. In the previous sections, we have discussed the challenges arising from delegation and existing theoretical approaches to address and analyze these. In a next step, we want to link these existing approaches to our work and, in particular, to the analyses in chapters 3 and 4. The analyses in the upcoming chapters examine how different aspects of uncertainty about a manager's ability changes his investment and effort incentives. We will first show, which aspects of uncertain ability may have an influence on managerial behavior. Then, we will describe how existing approaches can be extended to analyze the influence of these aspects.

A manager's skills and specific knowledge determine his productivity and the quality of his decisions. The more capable a manager is, i.e., the higher his ability, the more likely will he take the right decisions. Moreover, since a manager of higher ability is more productive, he should have stronger incentives to work hard. Hence, ability is one of the essential determinants for a manager's behavior and the quality

[66]Next to these two types of equilibrium other less commonly used equilibrium concepts exist, which are not used in this work. See Wilson (1977) or Riley (1979).
[67]See Kreps (1990) or Mas-Colell and Whinston and Green (1995), chapter 13 for further details on adverse selection.

of his work.

Ability, however, is not a directly observable or measurable metric. Rather than that, in the relationship between an owner and a manager, uncertainty about ability may arise in two forms (or a mixture of both):

- The owner (and external market) may only have an imperfect assessment of the manager's exact skills and ability or,
- the manager himself may not know it.

If the owner and the market do not know the manager's ability, they form beliefs about it based on the performance of the manager they can observe. These beliefs are commonly referred to as the manager's reputation. The manager, on the other hand, is aware of the market forming beliefs about his ability. Therefore, he considers effects on his reputation when taking decisions. In other words, reputation concerns change the manager's behavior.

From the point of view of the principal this may lead to both forms of problems we have discussed in the previous sections: an incentive and a selection problem. The manager may choose to take only those actions that improves his own reputation.[68] He may, for example, invest in prestigious projects, even when these have a high risk of not being profitable. Reputation may thus increase the conflict of interest between manager and owner and create additional incentive for the manager to not behave in the company's best interest.[69] In addition, a manager of low ability may take even higher risks to increase his own reputation and "mimic" a good manager. This last aspect then leads to the selection problems we discussed in the previous chapter and may affect the owner's hiring decisions.

[68] See chapter 3 for a more thorough discussion on career concerns.

[69] Other reasons for conflicts of interest between managers and owners actively discussed in the literature include, e.g., differences in time horizon or the utility function.

In chapter 3, we analyze how this form of uncertainty affects a manager's investment decisions. We consider a manager who has just newly joined a company and takes over business from his predecessor. Since he is new to the company, we assume that he has superior information about his ability. Furthermore, he is interested in his reputation, i.e. we assume that he will have a gain in utility if he can improve his reputation. A large number of empirical studies in the last decades has analyzed various aspects of this setting of executive turnover.[70] Especially, the effects of executive turnover on company performance and its determinants has been examined in many different settings.[71]

Our findings contribute to the existing literature in several ways. Most importantly, we find that reputation can change a manager's investment decision significantly. For example, we can demonstrate that reputation and career concerns provide one possible explanation for empirical findings that new managers tend to reverse investment decisions of their predecessor found, e.g., by Weisbach (1995). Furthermore, we can show that a manager's experience, i.e. age and tenure, have an influence on his behavior as the decrease the likelihood for strategic change. Hence, career concerns give an explanation for another well established empirical result.[72] Since a more detailed discussion of our results and their contribution to the existing empirical literature is given in chapter 3, we skip a more detailed summary at this point.

The second form of uncertainty that a manager may not know his own ability is more characteristic for young executives, who have only gained a limited level of experience yet. Due to this lack in experience, they may not know their skills yet. Instead, they form beliefs about their ability. These beliefs are then updated as they observe the output of their work and with it the quality of their previous decisions. New

[70]See Kesner and Sebora (1994) and Brickley (2003) for a review of the literature. In chapter 3, a more detailed discussion of the empirical literature is provided.
[71]See, e.g., Friedman and Singh(1989).
[72]See, e.g. Wiersema and Bantel (1992) or Huson et al. (2004).

decisions they have to make, take these learnings into account and, therefore, strongly depend on the way the manager learns.

In the beginning of a career, when only limited information is available, there is still a high level of uncertainty in the assessment of a manager about his ability. New information may, thus, still have a large influence on the manager's beliefs and on his behavior. After a long career with a history of many past successes and failures, this uncertainty slowly decreases. The impact of new information on the manager's beliefs is small. His behavior becomes less 'volatile'. The level of uncertainty about the manager's ability on his own side has a significant influence on his behavior.

In chapter 4, we will look at exactly this form of uncertainty, in which the manager[73] does not know his own ability, but learns it over time. In order to analyze how a manager's effort incentives depend on the assessment of his own ability, we assume that he learns with a self-attribution bias. A manager with self-attribution bias will take too much credit for successes he observes. We will see, how the way he learns – fully rational or biased – will change his behavior and have implications on the way the owner should create incentives. Chapter 4 demonstrates that classical theoretical results on effort incentives strongly depend on how the manager assesses his own ability. Hence, this chapter especially contributes to existing theoretical literature.

2.3.2. Classification of the Behavioral Extensions in this Work. Before we go into the analyses we want to briefly classify the theoretical model extensions we use in the two upcoming chapters from a purely modeling perspective. Both of the models extend existing approaches by integrating common human features in the context of uncertain ability. As we have seen, early model approaches analyzing the principal-agent relationship are built under very clear premises. Both players are assumed to act purely rationally and opportunistic. For

[73]And the owner.

example in case of the original moral hazard model, they have a very easy utility function depending on some (monetary) wage. The only non-monetary assumption made was that the agent bears costs for his effort. The rationale behind this and other models was that of a *homo oeconomicus*.[74]

In recent years, models – especially in finance[75] – started to include features from human behavior. At first this was mainly done in an attempt to explain observations, classical models could not.[76] More recently, behavioral aspects have found their way into a large variety of business research fields.[77]

From a modeling perspective, these behavioral features can be separated into two groups. The first group consists of those human characteristics that change the agent's utility function. For example, when an agent exhibits gloating, he may profit from another agent's low output. An envious agent may suffer from another agent's high level of utility.[78] On the contrary, the second group contains features of irrationality with no direct linkage to the agent's utility function. Rather than that, these characteristics change more general assumptions of rationality within the model, like the agent's thoughts about other players or the general environment. An example for this is the "representative heuristic". It says that people tend to see patterns in truly random sequences.[79] An agent with this feature will update probabilities in a non-rational way.

In the following analyses in chapters 3 and 4, we will examine a behavioral extension of each of these two groups. First, we will look

[74] This idea of the "Economic Man" goes back to Mill (1874).
[75] See Subrahmanyam (2008) for a recent overview on topics of behavioral finance.
[76] Barberis, Shleifer and Vishny (1998) and Daniel, Hirshleifer and Subrahmanyam (1998) use behavioral features to explain stock market over- and underreaction.
[77] See Sandner (2007), chapter 3, for an overview of the existing literature.
[78] See Bartling and Siemens (2009).
[79] See Barberis, Shleifer and Vishny (1998).

at a model with career concerns. As part of the analysis analysis, we model that the manager does not only benefit from his monetary wage, but also from a good market reputation as this may lead to valuable career options in the future. Hence, this career concerns model is an example of the second form of behavioral extension. After that, we will examine effects of self-attribution bias. This bias changes the way the agent learns and is, therefore, an example of the second form of behavioral extension. A detailed description of these two characteristics and the rationale behind them is given in the corresponding chapters.

CHAPTER 3

Effects of Reputation Concerns on Investment Incentives After an Executive Turnover

In this chapter, we want to analyze the first of the two forms of uncertainty about a manager's ability we discussed in the previous chapter. We consider a situation, in which a new manager has just newly joined a company. He has to take an divest invest decision for a strategic project he took over from his predecessor. The goal of this chapter is to gain an understanding of how a manager, who cares strongly about his reputation, decides in this divest decision as compared to a manager who would not care about his reputation. In other words, how reputation concerns influence a newly hired manager's investment decision.

3.1. Executive Turnover, Reputation, and Investment Behavior

Recent studies, both empirical and theoretical, have suggested a link between executive turnover and strategic change.[1] Newly hired managers tend to initiate major changes after taking over business. They often do this regardless of the previous company success and therefore of the real need for change. A recent example to demonstrate this idea is the history of Deutsche Telekom with its CEO changes from Ron Sommer to Kai-Uwe Ricke and finally to current CEO René Obermann. Over the last fifteen years, following these changes in top management, Deutsche Telekom constantly changed its organizational structure and strategic focus: It excluded its internet division T-Online

[1]See, e.g., Wiersema and Bantel (1993); Greiner and Bhambri (1989); Weisbach (1995); Sliwka (2001).

just to reinclude it only a few years later. It moved from four business units (under Ron Sommer) to three business units (with Kai-Uwe Ricke) to only two (René Obermann). Central parts of their business, like the fixed line unit T-Com, were merged with other units and renamed from T-Com to T-Home to Telekom. Other large companies with a long history of executive turnover, like Siemens, have shown similar changes in organization and strategy. Empirical studies support this anecdotal evidence, by showing that the likelihood of change and divestures is increasing at the time of executive turnover. Weisbach (1995), e.g, provides evidence that newly hired CEOs tend to reverse investment decisions previously made by their predecessors. He also finds that his results are independent of the reasons for the executive turnover. Kelly (1980) presents evidence that newly hired CEOs first change organizational infrastructure before they change the company's strategy. Denis and Denis (1995) find that executive turnover is related to changes in asset restructuring and the level of corporate control activity. Furthermore, the overall number of top executive turnovers has increased over the last years[2] making this field of research yet more important for future research.

In this chapter, we examine the setting of a new manager entering a company and taking over business in a dynamic adverse selection model with asymmetric information. We distinguish between managers of high and of low ability. The manager's ability is his private information, the external market only "knows" his reputation, i.e. its belief about his ability. The newly hired manager has to decide whether he wants to cancel an important ongoing strategic investment project and replace it with one of his own or keep it. If he cancels the old project, the probability that the new one is successful is influenced by the his own ability. The project's real profitability is unknown during the game. He and the owner have, however, a signal about the project's

[2]See, e.g. Kaplan and Minton (2006).

expected profitability.

When the manager makes his cancelation decision, this decision provides new information about the manager's ability. The external market will update his beliefs about the manager's ability. According to well established stream of literature that focuses on career concerns, we assume that the manager is interested in his market reputation and gains utility from this reputation. Hence, in the divest decision, he will consider its influence on his reputation.

The analysis of our model in this chapter yields the following main results. (1) Without career concerns, the manager behaves in the owner's best interest. No conflict of interest arises. (2) In the presence of career concerns, managers of high ability are more likely to cancel existing projects than managers of low ability. (3) If the manager is interested in his market reputation an equilibrium exists that managers will tend to cancel every project disregarding all positive signals about its profitability. A conflict of interest between the owner an the manager arises. (4) This effect is stronger, the better the reputation of the preceding manager is. (5) In case of internal succession, managers are more reluctant to cancel ongoing projects since they were usually involved in the project prior to management turnover. (5a) If the new manager was not too strongly involved in the project, the equilibrium that the manager cancels every project arises less often. (5b) If he was strongly involved in the project, an equilibrium exists in which the manager does not cancel any project even if the signal suggests it is a failure.

This chapter contributes and is related to two streams of literature: the afore mentioned career concerns literature and the literature on executive turnover and its influence on managerial and company performance.

The rationale behind the career concerns literature is as follows. In addition to explicit incentives created, e.g., by a compensation contract implicit incentives for a manager arise. These implicit incentives are based on the assumption that actions[3] taken today influence the market's expectations in the future. Therefore, these actions may change a manager's career opportunities.[4] A manager interested in his career will consider these implicit incentives when choosing his actions. This is prevalently called career concerns.[5]

Career concerns problems can arise in multi-period principal-agent settings.[6] They are defined by a situation in which potential career options in the future may have undesirable effects on the agent's behavior today.[7] The agent is interested in having a good market reputation and, therefore, acts in ways to improve it. Actions that improve the agent's reputation may, however, not always be in the principal's best interest. For example, an agent may decide to hide certain private information that would reduce his reputation, such as profitability information regarding one of his investment projects. Career concerns problems are of high importance for labor markets - especially that of top level executives.[8] We will analyze the behavior of a newly hired manager, who is concerned in his career and, therefore, his market reputation after a management turnover.

Theoretical research on career concerns, using a principal-agent model, go back to Holmström (1982a) and (1999) as well as Holmström and Ricart i Costa (1986). Focus of the first models of Holmström was the influence of career concerns on managerial incentives with moral

[3]Such as effort or investment decisions.
[4]See Kräkel (2004).
[5]See Holmström (1982a) and (1999).
[6]For an overview on career concern problems see Borland (2006) or Kräkel (2004), pp. 192-202.
[7]See Kräkel (1999) and (2004), p. 191.
[8]See Borland (2006).

hazard.[9] Other models that are more closely related to this work analyze the influence of career and reputation concerns on the manager's investment decisions.[10]

Our analysis and modeling is very similar to a recent work by Sliwka (2007) who also investigates a manager's investment behavior in an adverse selection career concerns model with executive turnover. In his model, an incumbent manager has to decide whether to cancel or keep an existing strategic project he originally initiated based on a profitability signal from accounting. Like in our model, the manager faces a trade-off between following the signal and potential negative effects this might have for his reputation. As a result of this trade-off, he shows that especially good managers are reluctant to change decisions they once took themselves even if new information indicates that these decisions were wrong. Therefore, Sliwka shows that management turnover can be an instrument to enforce strategic change.

In contrast to our model, Sliwka looks at a pre-turnover setting: An incumbent manager has to review his own decision and the owner may replace this manager to enforce strategic change. In our setting, we look at a post-turnover situation in which a new manager reviews a decision by his predecessor. The basic modeling of reputation as part of the manager's long term utility function in our model is the same. Our findings show that the result of management turnover enforcing strategic change also determines the investment behavior of the new manager after turnover. Moreover, contrary to incumbent managers' reluctancy towards change, we show that new managers are 'too eager' to change existing projects in the sense that they cancel even profitable projects to increase their own reputation.

[9]At the end of Holmstöm (1982a) he also addresses a manager's investment behavior.

[10]See Narayan (1985a) and (1985b); Kanodia, Bushman and Dickhaut (1989); Scharfstein and Stein; Boot (1992).

Besides questions of investment behavior, career concerns models are also used to analyze different unrelated settings such as brand extensions, choice of performance measures and diversification.[11] This shows that career concerns models have been widely used and accepted in different fields and questions of current research.

The second related stream of literature is that examining the effects of executive turnover. Due to the importance of managerial decision making for a company's success, executive turnover has been subject of various empirical studies in the past with a wide variety of topics examined. Those studies examining the relationship between executive turnover and strategic change are most closely related our work. Our results provide one possible explanation for the findings of, e.g., Weisbach (1995) that new managers tend to reverse investments made by their predecessor. We show that this empirical finding may be due to career concerns and reasons of reputation. A new manager may have an incentive to reverse existing investments in order to differentiate himself from his predecessor and build up his own reputation.

Secondly, our analysis sheds additional light on the relationship between CEO turnover and company performance. Previous results on the relationship provided equivocal and partly contrary results. While it is common consensus that CEO turnover and pre-turnover firm success are correlated,[12] the correlation between post-turnover company performance (or firm value) and CEO turnover has proven to be more complex. As it appears, a wide range of factors and determinants have a large influence on post-turnover performance. Studies, especially more recent ones, have tried to analyze these different determinants of post-turnover performance. Most studies show increased firm performance following CEO succession. Differences, however, seem to exist between

[11]See, e.g., Bebchuk and Stole (1993); Cabral (2000); Arya and Mittendorf (2008).
[12]See Brickley (2003).

internal and external succession, forced or voluntary turnover or positive and negative pre-turnover performance[13]. Older research, which found little or no influence of managerial turnover on firm performance and firm value[14] tried to explain their findings using the argument that firing is often used as an instrument of scapegoating.

Our results contribute to identifying possible determinants for the relationship between pre- and post-turnover performance. First of all, our findings suggest that especially for well-performing companies executive turnover should have negative implications on company performance.[15] Our finding is due to the strong tendency of new managers towards strategic change. For a poor-performing company, strategic change bears new chances for performance to increase. For a well-performing company, however, a manager who will change existing strategies disregarding their current success, is more likely to destroy company value.

In addition to that, we find that external succession is better for poorly performing companies while internal succession reduces risks for unnecessary change and is, thus, more appropriate for well-performing firms. Our results, therefore, support empirical findings that positive post-turnover firm performance is more likely for weak pre-turnover performance as stated, e.g., by Friedman and Singh (1989). Furthermore, we are consistent with findings like those of Wiersema (1992) or Huson et al. (2004) that external succession will more likely lead to strategic change and better post-turnover performance for weakly performing companies. Notice, however, that empirical studies draw a highly ambiguous picture with contrary results. In particular, due to the complexity of the underlying determinants, there is a countless

[13]See, e.g., Friedman and Singh (1989); Wiersema (1992); Denis and Denis (1995); Weisbach (1995); Huson et. al (2004).

[14]See, e.g., Brown (1982); Lieberson and O'Connor (1972).

[15]Empirical literature on this topic is highly inconsistent since many has many determining factors. See Kesner and Sebora (1994).

number of studies with no or different results.[16] Our results, hence, suggest further analyses, which specifically control for pre-turnover performance and the type of succession.

Finally, our results emphasize the fact that a manager's age and tenure reduce the likelihood of strategic change. This was pointed out by a number of empirical studies, like, for instance, Grimm and Smith (1991), Wiersema and Bantel (1992) or Brickley (2003). We show that the tendency towards change is due to the manager's wish to improve or establish his reputation. This factor, however, is strongest when there is still a high level of uncertainty about his ability in the market. With age and tenure this effect loses importance, as the market has already formed a strong belief about the manager's ability. A single observation does no longer have an effect as strong as in the beginning of the career. Therefore, the willingness to change for reasons of reputation decreases and so does overall likelihood of change.

For an overview of the empirical literature on CEO turnover see Brickley (2003). A summary of the research about CEO succession and its determinants is given by Kesner and Sebora (1994).

The analysis in this work can be seen as at the interface of these two streams of literature. Besides this model and the afore mentioned one of Sliwka (2007), other similar models, which also combine the two streams, exist.[17] These models focus on the owner's firing decision and show how it can lead to strategic change, subordinate motivation or scapegoating. Our focus is not the influence of forced turnover. Rather, we examine managerial investment behavior in light of career concerns and the impact of the owner's hiring decision.

[16] See Kesner and Sebora (1994) for a detailed overview of the studies of the last 30 years.

[17] See, e.g., Hoeffler and Sliwka (2003); Dezsö (2004).

The structure of the remainder of this chapter is as follows. In section 2 the basic career concerns model is developed to analyze the manager's post-turnover investment behavior. The equilibria of the game are derived. In section 3 the model is extended to differentiate the effects of internal and external succession. Section 4 concludes.

3.2. Analyzing Investment Behavior Following Executive Turnover

3.2.1. The Basic Model. We consider a situation in which a company owner O (*she*), delegates management decisions to a hired manager. Both of these are risk neutral. In contrast to before, we further assume that the management of the company has just changed, i.e., that we have a new manager M_{new} (*he*) . This manager just took over his position and the ongoing business of the company from some former manager – his predecessor. At this point of the analysis, we will not look at the exact circumstances of this management turnover, but just take the change as a fact. In a later model extension, we will then differentiate between internal and external succession.[18] Later, it will be necessary to refer to the preceding manager, who just left the company. We will refer to him as M_{pre}. For this manager, the players share a common belief about his ability – the predecessors reputation $\hat{a}_{pre}$. This does not change during the game, but can be treated as an exogenous variable.

The new manager has a certain managerial ability a, which determines how well he can perform in his job. He can be of either high ability, i.e. $a = a_H$, or of low ability, i.e. $a = a_L$, with $\frac{1}{2} < a_L < a_H$.[19] The ability a of the manager is his private information.. We assume that nature chooses it at the beginning of the game in period 0. The owner and the outside market share an ex ante belief about the manager's ability. This is given by the probability η that he is of high

[18]See section 3.3 for further details.
[19]We assume that all managers can only be of high or low ability.

ability, i.e., $\Pr[a = a_H] = \eta$. This probability η is the result of the manager's previous success at work, as observed by the market. Very closely related is what we call the manager's reputation.

The reputation of the new manager at time t is given by

$$\hat{a}_t = E\left[a \,|H_t\right],$$

where H_t is the game's history up to period t, i.e. the information the market has obtained up to t. This notion of reputation follows the intuition that reputation is the manager's ability as perceived by the market. For ease of notation, we will sometimes just use $\hat{a}$ for the initial reputation at the beginning of the game instead of the formally correct term $\hat{a}_1$. The manager's initial reputation at the beginning of the game in $t = 1$ is given by

$$\hat{a} = \hat{a}_1 = \eta \cdot a_H + (1 - \eta) \cdot a_L.$$

The reputation of the manager changes during the game as the market observes the manager's behavior and the outcome of his work. The manager is aware, what effect his actions might have on the external assessment of his ability. This fact will be essential for this chapter's further analysis.

The manager is hired to perform two tasks: A strategic investment and an operational task. The first one consists of investing the existing limited resources in an overall strategic project that determines the long-term success of the company. The latter is determined by daily operational business the manager needs to do to keep the company running. The manager's potential success in both of these tasks depends on his ability.

We first look at the strategic investment task in more detail. Extending most of the existing approaches, which neglect past investment activity, we assume that the company's business is up and running.

Specifically, we consider a situation in which there is an ongoing strategic investment in form of a project P which uses considerable resources. This project $P \in \{\Pi_{inv}, 0\}$ can either be profitable, i.e., $P = \Pi_{inv}$, or not, i.e., $P = 0$. While the project is still running, the profitability is unknown to the manager, the owner and the external market. Only at the end of the game, the project will create payoffs for the owner according to its profitability. These payoffs will be publicly observable.

During the game, the manager and owner will, however, receive a signal s predicting the profitability of the ongoing project. This signal is not available to the external market. It is a leading indicator of the project's future success, coming, e.g., from the company's internal accounting systems. Just like the project, the signal can either indicate succes, $s = \Pi_{inv}$, or failure, $s = 0$. We further assume that the quality of the signal is $\sigma < 1$. More precisely we have

$$\Pr\left[P = \Pi_{inv} \left| s = \Pi_{inv}\right.\right] = \Pr\left[P = 0 \left| s = 0\right.\right] = \sigma.$$

In general, the profitability of a project P is determined by the ability of its initiator $\iota(P)$. If a_i is the ability of the project P's initiator, then its profitability is given by

$$\Pr\left[P = \Pi_{inv}\right] = a_i.$$

Due to this link between a project's profitability and its initiator's ability, it is important to know the initiator. Since the ability is not known to the market, the project's outcome will give a signal about the initiator's ability to the external market.

At the beginning of the game, it is the new manager's decision how to treat the ongoing project P. He has two options. He can either leave the project as it is, the decision denoted $\delta = K$, or he can decide to cancel the project and reinvest the free resources in a new project, denoted $\delta = C$. In the latter case, project P gets replaced by a new project $\tilde{P} \in \{\Pi_{inv}, 0\}$. We assume that resources are limited so that the manager is not completely free in his investment decisions. In particular he cannot invest in an arbitrary number of projects at the same time. While the initiator of the old project was M_{pre}, we would then have $\iota(\tilde{P}) = M_{new}$. The expected profitability would depend solely on the new manager's ability, i.e.

$$\Pr\left[\tilde{P} = \Pi_{inv}\right] = a.$$

The decision the manager makes about whether to cancel or keep the project can be observed by both the owner and the outside market.[20] We assume that it is always in the owner's best interest to keep a project with a positive signal $s = \Pi_{inv}$ regardless of the new manager's ability. This means that the quality of the signal is sufficiently large, i.e. $\sigma > a_H > a_L$. In our later analysis, due to this fact the manager faces a trade-off in his decision. On the one hand, he wants to increase the company's expected prospects by keeping profitable projects. On the other hand, he could improve his own reputation by initiating a successful project of his own.

Besides the strategic project, the manager works on (every day) operational business. We assume that this business and especially its success is fully determined by the manager's ability. At time $t = 2$ the company and, hence, the owner receives operational payoff π_{op} from this task. We assume that

$$\pi_{op} = \begin{cases} \Pi_{op} & \text{, for } a = a_H \\ 0 & \text{, for } a = a_L. \end{cases}$$

Therefore, after this payoff is observed, the information asymmetry about the manager's ability between the owner and the manager is resolved. Both owner and manager then know M_{new}'s true ability.[21]

[20] Remember, the owner has superior knowledge. Unlike the external market, he knows the internal signal s indicating the profitability of the project.

[21] Since we do not consider a firing decision in this model, this will, however, not have a direct implication to the following analysis.

Looking at the payoffs of the game and resulting utility for the two players, we get the following setting. First, the operational payoff is achieved in period 2. It is entirely consumed by the owner of the company. The manager only participates in the company's long-term strategic success represented by the investment project. Second, the strategic project's payoff is achieved in the final period 3 of the game.

The manager's overall utility π_M at the end of the game consists of two components: an investment component from the strategic project π_{inv} and a reputation component π_{rep}.

$$\pi_M = \pi_{inv} + \pi_{rep}$$

The first part is his share of the project's payoff. It is simply given by

$$\pi_{inv} = \begin{cases} \alpha \cdot P & \delta = K \\ \alpha \cdot \tilde{P} & \delta = C, \end{cases}$$

where $\alpha < 1$ is a given fixed share from a linear compensation contract.[22] We call the utility the manager gets, if the project is a success ω_P, with

$$\omega_P := \alpha \cdot \Pi_{inv}.$$

So, his utility from the strategic project can be either ω_P in case of a success or 0 in case of a failure.

The second part of his utility is reputation utility. It is determined by the manager's reputation at the end of the game, i.e.,

$$\pi_{rep} = \hat{a}_3 \cdot \omega_R,$$

where ω_R is a constant measuring the importance of reputation to the manager. We assume that the manager gains utility from his reputation for reasons of career concerns. A better market reputation could,

[22] Note that we do not focus on determining the optimal bonus contract. Rather, we analyze the manager's behavior in the presence of career concerns.

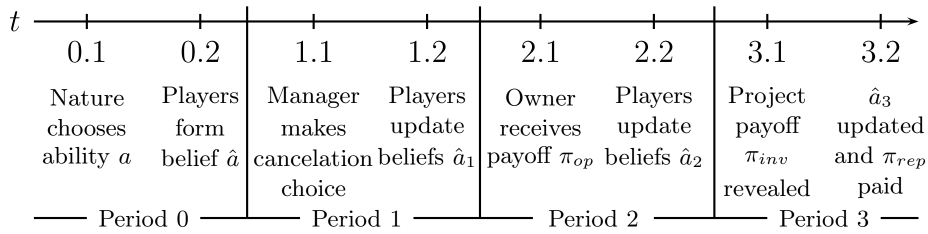

FIGURE 1. The basic game's timeline of the model in chapter 3.

for example, give the manager higher paid job opportunities in the future.[23] Therefore, π_{rep} captures these long-term prospects due to career concerns.

The manager's reputation $\hat{a}_t$ changes during the game, when new information regarding the manager's ability becomes available to the external market. The market observes the manager's cancelation decision and the project outcome and draws conclusions upon the manager's ability a. Note that the market's updated beliefs due to the cancelation decision depend on the different behavior of the two types of managers in equilibrium. The behavior of the manager depends on how strongly he weighs reputation effects, ω_R, as compared to the potential monetary project payoff, ω_P.

The owner's overall utility π_O consists of the full operational payoff π_{op} and the residual payoff from the strategic project:

$$\pi_O = \pi_{op} + \begin{cases} (1-\alpha) \cdot P & \delta = K \\ (1-\alpha) \cdot \tilde{P} & \delta = C. \end{cases}$$

Table 1 summarizes the timeline of this basic model. Later, we will extend this basic model to capture and analyze the specific effects of internal vs. external executive succession. In the forthcoming section, we will study the manager's incentives due to the structure of his utility

[23]See the previous section for an overview on career concerns.

function and derive its implications on the two types of managers' behavior – high or low ability – in equilibrium.

3.2.2. Reputation Concerns and Managerial Investment Behavior. In the following section we want to analyze the implications of the manager's career concerns on his decisions regarding the ongoing project. Accordingly, we have to identify the new manager's behavior in equilibrium contingent on both types of managers' utility function. The concept used throughout the following analysis will be that of perfect bayesian equilibrium.

As a first conclusion from the setting described above, note that in any pooling equilibrium the manager's reputation remains unchanged if he decides not to cancel the project. This is the case since the success or failure of a project will only change reputation of its initiator.[24] On the other hand, for a non pooling equilibrium the cancellation decision itself may, of course, give the market new information regarding the manager's type.

The following analysis is determined by the two parts of the manager's utility function: payouts from the project and benefits from reputation. The expected prospects from the ongoing success do not depend on *his* ability but only on that of the initiator – his *predecessor*. On the other hand, by his cancelation decision he is able to give the external market a new signal about his ability. This may lead to an increased reputation and related utility. He, therefore, faces a trade-off of choosing between payout from the ongoing project and prospects from increased reputation.

To find out whether it is optimal for the manager to cancel or keep the project, we have to compare expected prospects for both of these options. We do this by evaluating the *changes* in utility that result

[24]Since in pooling equilibrium both types of managers do the same, the market cannot derive new information from the mere fact that a manager has or has not canceled a project.

from canceling the project instead of keeping it. These changes from canceling will be denoted as $\Delta\pi_{inv}$, for project payoff, and $\Delta\pi_{rep}$, for the reputation prospects. A manager will decide to cancel a project if and only if these two (possibly contrary effects) will yield an expected positive payoff, i.e., $E[\Delta\pi_{rep} + \Delta\pi_{inv}] \geq 0$.

We will first look at the effects from project payoff. This first part is straightforward. Expected utility from starting a new project solely depends on the ability of the manager and the profitability signal s of the old project. As we have seen, a manager of high ability is more likely to start a profitable project. Thus, his expected utility from project success is always larger than that of a low ability manager. Note, however, that by definition the payoff from canceling a profitable project is negative for both types, i.e., $\Delta\pi_{inv} < 0$. The following proposition summarizes the effects the cancelation of the project has on π_{inv}:

Proposition 3.2.1. *Let $\omega_P = \alpha\Pi_{inv}$ be the manager's utility in case of a successful project payoff. In $t = 1$, when he has to decide how to treat the ongoing project P in period 1, we get the following results.*

(i) *The change in the manager's expected utility from project payoff, when canceling the project P is given by*

$$\Delta\pi_{inv} = \begin{cases} \omega_P \cdot (a - \sigma) & \text{, for } s = \Pi_{inv} \\ \omega_P \cdot (a - (1 - \sigma)) & \text{, for } s = 0 \end{cases}$$

with $\Delta\pi_{inv} < 0$ for $s = \Pi_{inv}$ and $\Delta\pi_{inv} > 0$ for $s = 0$. 8

(ii) *$\Delta\pi_{inv}$ is strictly increasing in the manager's ability a. In particular, a manager of high ability will, regardless of the signal s, always gain more (or to put it differently lose less) from canceling a project than one of lower ability.*

□

The intuition behind the fact that the cancelation of a profitable project is less costly for a manager of high ability is because he can be more confident about the success of his own newly initiated project.

The payoffs do depend on the quality σ of the signal s. As the certainty of the signal raises, it gets more profitable to follow the signal. Conversely, deciding against the signal yields lower expected payoffs.

A direct implication of the proposition above is as follows. Without the reputation utility, it is always in the manager's best interest to follow the recommendation derived from the signal s. The manager would always behave in the owner's best interest. When effects on reputation are also considered, this no longer holds, as the following analysis shows.

The effects of a cancelation decision on the manager's reputation are more subtle to calculate. Recall that we defined π_{rep} as the newly hired manager's reputation $\hat{a}_3$ at the end of the game, weighted with some constant ω_R. This factor represents how important reputation for the manager is. The reputation at the end of the game depends on two factors: initial reputation and the manager's ability. First, it is determined by the manager's initial market reputation when he enters the company $\hat{a}$. Secondly, the manager's true ability a will influence his decisions during the game and, therefore, has an impact on his reputation at the end of the game: If the manager decides to cancel the project, the success of his new project depends on his ability. Thus, the observed project outcome in that case changes his reputation. Consequently, at the time he makes the decision the manager takes into account the expected reputation effect of canceling. For that, he has to compare his reputation in case of a success outcome to that in case of a failure.

To illustrate this, let $\tilde{a}|_S$ be the (ex ante) expected reputation at the end of the game when M_{new} decides to cancel the ongoing project and his new project turns out to be a success, i.e.,

$$\tilde{a}|_S = E\left[\hat{a}_3 \,\middle|\, \delta = C \wedge \tilde{P} = S\right] = \tilde{\eta}|_S a_H + (1 - \tilde{\eta}|S)a_L,$$

and let $\tilde{a}|_F$ be the according value if he cancels but his new project is a failure ($\tilde{P} = F$). Then the expected reputation utility of a manager of ability a is simply $E[\pi_{rep}] = a \cdot \tilde{a}|_S + (1-a) \cdot \tilde{a}|_F$.[25]

The arguments from above on the effects of a cancelation to the manager's utility yields a first result in our equilibrium analysis. Like suggested by proposition 3.2.1 (ii), we get that managers of high ability are more likely to cancel the ongoing project of the preceding manager in the following sense.

Lemma 3.2.2. *For any value of ω_P and ω_R, there will never be an equilibrium in which only a manager of low ability will cancel a given project whilst a high ability manager will keep it.* □

Using this lemma, we can now investigate the equilibria of the game. The behavior of a manager depends on how important reputation is compared to the potential monetary project payoff. This is represented by the ratio $\frac{\omega_R}{\omega_P}$. In order to determine perfect bayesian equilibria, we have to examine the different manager types' utility function. Expected utility, however, is not only determined by the manager's own strategy but also by the strategy a manager of different ability type would have in equilibrium.

When neglecting reputation, we have already seen that there is no conflict between the owner's and the manager's best interest. This fact also remains valid when the manager only cares little about his reputation. In this situation, reputation effects are not large enough to outweigh the incentives created by potential utility from project success.

On the other extreme, when the importance of reputation is very high, potential prospects from reputation outweigh potential losses that managers might suffer from canceling projects with a positive signal s.

[25]Note that $\tilde{a}|_S > \tilde{a}|_F$, as a successful project will never reduce the manager's reputation, whilst initiating a failing one might.

In other words, in this case both types of managers will cancel any project regardless of the profitability signal s. The following proposition summarizes these findings.

Proposition 3.2.3. *Consider the manager's cancelation decision in period* $t = 1$*.*

(i) *When the newly hired manager gains very little from having a good reputation, i.e., when the quotient* $\frac{\omega_R}{\omega_P}$ *is small, or when the uncertainty about the manager's ability is very small, i.e.,* $\hat{a} \approx a_L$ *or* $\hat{a} \approx a_H$*, an equilibrium exists in which both types of managers always behave in the owner's best interest and only cancel projects with a negative signal* $s = 0$*.*

(ii) *When the importance of reputation gain for the manager is very high, i.e., for high values of* $\frac{\omega_R}{\omega_P}$*, and when additionally the manager's initial reputation is high, i.e. for large values of* $\hat{a}$*, an equilibrium exists in which the manager cancels any project disregarding the profitability signal* s *and his true ability.*

□

Both of these equilibria are pooling equilibria. Hence, since both types of managers behave the same way, the outside market can update its beliefs solely based on the observed project success if he decides to cancel.

Looking at the two cases in detail, the equilibrium in (i) can only be sustained if there are no incentives to cancel profitable projects for a new manager of high ability.[26] The equilibrium in (ii), on the other hand, can only be achieved, once the importance of reputation is large enough for a manager of low ability to cancel a project with positive signal $s = \Pi_{inv}$.

[26]By lemma 3.2.2, this directly implies the same for a manager of low ability.

The requirement for (ii) that initial reputation $\hat{a}$ needs to be large enough seems counterintuitive at first. The reason for that is as follows. Since this is a pooling equilibrium where both types of managers cancel any given project, when a manager decides not to cancel a project, the market will know that this is a manager of low ability. This is due to the fact that a low ability manager is much more likely not to cancel a project. The higher the initial reputation is the more does the manager fear to loose this good reputation. Thus, a low ability manager will not depart from the equilibrium path. For the same reason, the change in reputation utility is much higher in case (ii) than it is in (i). When both players cancel all projects in equilibrium, the external market learns more about the manager's true ability in the off-equilibrium case than in (i) where only the project payoff provides new information about the agent's ability. Departing from the equilibrium path is much more costly in (ii) than in (i).

The exact payoffs from canceling as compared to keeping the project, i.e. $\Delta\pi_{rep}$, in these two cases are illustrated in figure 2. The equilibrium is reached when both graphs stay below – case (i) – or both exceed – case (ii) – the dotted horizontal line of the project utility π_{inv}. The dashed line, which represents reputation payoffs from canceling for the low ability manager, is always below the solid one of the high ability manager. In the case of (i), it is even negative. This shows that managers of low ability suffer a reputation loss when canceling a project in the case of equilibrium (i). Most notably, this means that even when a bad manager cancels a project which is signaled to be a failure $(s = 0)$ he faces reputation loss. However, this loss at low levels of $\frac{\omega_R}{\omega_P}$ is not large enough to outweigh the additional monetary prospects arising from canceling.

Besides the pooling equilibria of the previous proposition, the result of lemma 3.2.2 will lead to another, non-pooling, equilibrium. An equilibrium exists, in which only high ability managers cancel all projects.

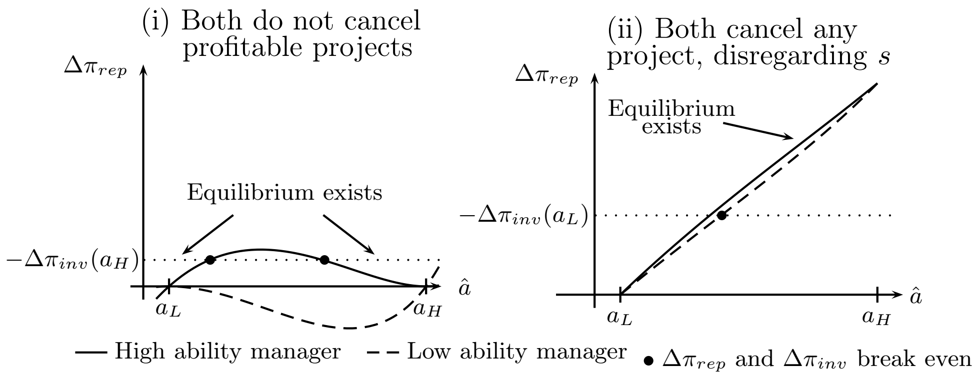

FIGURE 2. Utility from reputation compared to project utility for the two equilibrium cases of proposition 3.2.3.

Precisely, for intermediate importance of reputation, i.e. for intermediate values of $\frac{\omega_R}{\omega_P}$, an equilibrium exists, in which a high ability manager will cancel all projects and a manager of low ability will only cancel unprofitable ones. In this setting, keeping a project will give the market the information that the manager is of low ability. Therefore it can only be sustained if a low ability manager's loss in reputation is smaller than the potential loss from canceling profitable projects. This is summarized in the following proposition.

Proposition 3.2.4. *For the cancelation decision, we get a separating equilibrium in the following situation.*

(i) *When managers neither care too much nor too little about their reputation, i.e. for intermediate values of $\frac{\omega_R}{\omega_P}$, and when the manager's initial reputation $\hat{a}$ is large, an equilibrium exists in which low ability managers only cancel unprofitable projects whilst high ability managers cancel all projects.*

(ii) *The upper and lower bounds for which values of $\frac{\omega_R}{\omega_P}$ the equilibrium in (i) exists, depends on the reputation of the preceding manager. Specifically, the higher the preceding manager's reputation $\hat{a}_{pre}$ is, the smaller is the lower threshold level of $\frac{\omega_R}{\omega_P}$ for the equilibrium to exist. Conversely, the range, in which the equilibrium exists, is decreasing for larger $\hat{a}_{pre}$, i.e., the* *upper boundary is decreasing stronger than the lower threshold value.*

□

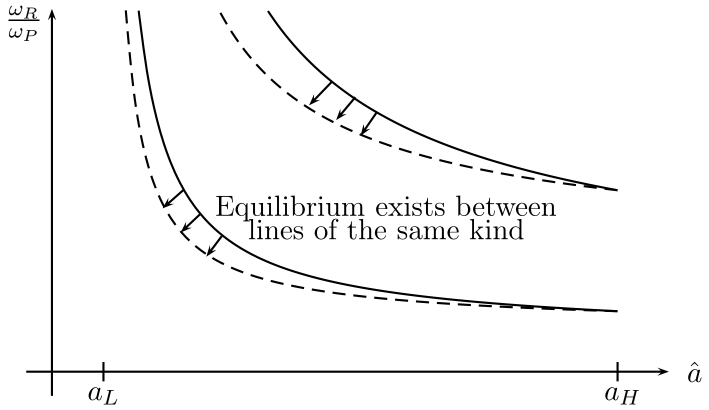

FIGURE 3. Changing threshold levels in the equilibrium of proposition 3.2.4: solid lines for low reputation predecessor ($\hat{a}_{pre} = a_L$), dashed lines for high ($\hat{a}_{pre} = a_H$); arrows indicate the change as $\hat{a}_{pre}$ increases.

The connection between the reputation $\hat{a}_{pre}$ of a preceding manager who is no longer working for the company is puzzling at first. The intuition behind it is that if the ongoing project was started by a manager of high ability, the market beliefs that it is less likely to be a failure. That means a signal $s = 0$ is less likely to occur. As the external market does not know the accounting signal s, the preceding manager's reputation is the best available information regarding project's success. This, however, means that the probability that the manager intentionally cancelled a profitable project rises in $\hat{a}_{pre}$. Since managers of high ability are more likely to take this step, a cancelation will signal a higher level of ability. Hence, the threshold level for this equilibrium rises in $\frac{\omega_R}{\omega_P}$.

On the other hand, this effect is even stronger for a low ability manager: The potential reputation gain for a low ability manager is therefore even larger. As a result, the threshold to leave this equilibrium – and cancel the project instead – is decreasing faster for a low ability manager than for one of high ability. The range in which the equilibrium is sustained becomes narrower for growing $\hat{a}_{pre}$. The higher the preceding manager's reputation is the more does canceling give the newly hired manager the chance to distinguish himself from his predecessor and potentially gain more in reputation. These changing threshold levels are illustrated in figure 3.

Another striking result of proposition 3.2.4 is that it reveals possible situations, in which the company might be better off with a manager of low ability. Managers with high ability are more likely to cancel profitable projects. This can destroy company value. In the light of career concerns, the owner's hiring strategy may become more complex as simply picking the candidate with the highest expected ability (i.e., reputation) available. We will further investigate the rationale behind a possible hiring decision in the next section. Before we do, figure 4 gives an overview of all the equilibrium results we have obtained so far.

3.2.3. The Influence of Career Concerns on the Hiring Decision and Management Contracts. Due to career concerns, a newly hired manager may not behave in the owner's best interest. This phenomenon consists of two aspects. On the one hand, new managers of high ability who care much about their reputation have an incentive to cancel potentially profitable projects. In other words, they have an incentive to stop all of their predecessor's business to gain in reputation from possible success of their own project. On the other hand, managers of low ability with high reputation may be afraid that the market learns about their true ability. Thus, they try to mimic a high ability manager's behavior and cancel profitable projects as well.

In this section, we analyze the influence of last section's results on the owner's hiring decision. We assume that she has to pick her new manager only based upon his reputation and the firm specific need for strategic change. In the forthcoming analysis, we suppose that the owner has a pool of potential candidates to choose her new manager

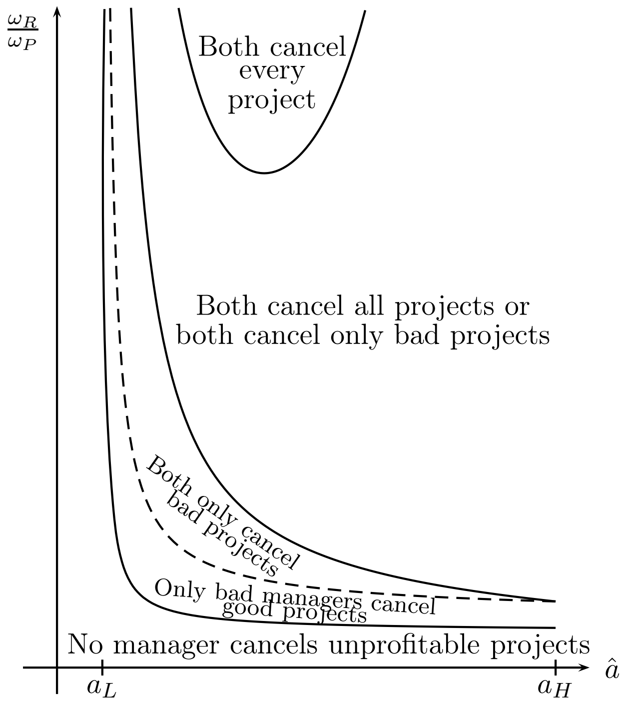

FIGURE 4. Equilibria of the game by parameter - importance of reputation determines the manager's behavior in equilibrium.

from. In reality this may not always be the case. For our analysis this assumption can be relaxed to the requirement that there are always enough managers with a poor reputation.[27] Note that without career concerns the hiring decision would be easy. The owner would pick the manager with the best reputation, i.e., the one who is most likely of high ability. We consider a situation in which the owner has to hire a new manager. The owner knows the profitability signal s and will therefore include it in her hiring decision.

To determine the owner's optimal hiring decision, we have to analyze her expected utility depending on her decision. Her utility is determined by the project's profitability and the operational payoff π_{op}.

[27]This assumption, on the contrary, appears to be reasonable, since especially management rookies will not have a high reputation right from the beginning of their career.

The operational payoff is fully determined by the new manager's ability. This means that if the owner decides not to hire the best available candidate, her expected utility from operations $E[\pi_{op}]$ will decrease. On the other hand, the higher the newly hired manager's reputation is, the more likely is he to cancel profitable projects. The owner therefore faces a trade-off between these two parts of her utility.

The owner's optimal hiring decision depends on the profitability signal s. If the signal indicates that the ongoing project is a failure, i.e. $s = 0$, the analysis is straight forward. High ability managers have a greater tendency to cancel existing projects from their predecessor and are also more likely to create higher operational prospects. The owner will pick the manager with the highest reputation $\hat{a}$ available to take over business and maximize her utility.

If the project is signaled to be a success, i.e. $s = \Pi_{inv}$, this becomes more complex. On the one hand, the owner wants a manager with high ability to maximize expected operational payoff $E[\pi_{op}]$ and to have a good manager for future investment decisions. On the other hand, a manager with lower reputation may be more likely to behave in her best interest and keep the profitable project. As a direct result of the previous section's equilibrium analysis, we get the following results.

Proposition 3.2.5. *Let the business of a company be running well, i.e., internal profitability signal s indicates success. Further assume that the ongoing strategic investment project P is of significant importance as compared to other daily operational business, i.e., $\frac{\Pi_{inv}}{\Pi_{op}}$ is sufficiently large. Then, for medium values of $\frac{\omega_R}{\omega_P}$, we get the following results.*

(i) *If the owner cannot effectively, e.g. as part of a contract, detain the manager from canceling the ongoing project, then there may be a situation, in which hiring the candidate with the best reputation will not maximize the owner's expected utility.*

(ii) *If the owner can prohibit project cancelation, she should do so.*

□

For the case of failure, i.e. $s = 0$, the rationale for the hiring decision follows the line of argument from above. One might argue that the owner should simply include conditions regarding the future of the project in the contract between her and the new manager. However, since we assume that this project represents an essential part of overall company strategy, defining exactly how the manager has to handle the project bears severe limitations and foils the idea of managerial delegation. In reality, the situation might, therefore, be a mixture of the two cases above. The owner might bear certain costs when limiting the manager's scope of decision making, for example, by reducing the attractiveness of the position. Managers of high ability and reputation may not be willing to accept a contract with such constraints or may want a premium to accept it. However, both cases[28] show that the effects of the previous section may influence both the hiring decision and the contractual arrangement.

The result not to hire the best manager available appears counter-intuitive at first. The intuition behind it is that there may be situations, in which the owner has such a strong interest in bringing the company's ongoing projects to a (presumably) successful ending that this might even outweigh negative effects the company may suffer from not choosing the best manager available. The owner trades possible operational utility π_{op} against strategic stability.[29] These results show that high reputation managers' tendency to cancel existing projects, disregarding their profitability, induce further complexity into the owner's hiring and contractual process. The company's overall pre-turnover success

[28]Or a combination of the two.

[29]In reality the situation is far more complex and the benefits from having a manager of high ability have many dimensions to it.

should be considered in hiring and contracting decisions.

Owners try to get the best manager available to run their companies. However, the better their business is running, i.e., the better the ongoing projects from the previous manager are, the larger incentives get, not to hire the best manager to prevent project change. Our results give one possible explanation for existing empirical findings that managerial turnover has negative effects on well performing companies.[30] We state that one reason for that may be career concerns of the new manager, who will be too eager to change existing business. In case, the existing business is poorly performing, this is not a problem and even in the owner's best interest. If, however, the new manager takes over a well performing business, his eagerness to change existing projects may jeopardize existing company success. The manager may cancel profitable projects only to replace them with his own in order to be linked to their potential success. For reasons of reputation, he will do this even when he knows that his own projects are less likely to be a success.

In the next section, we extend this analysis by differentiating between two types of management turnover: internal succession and external succession.

3.3. Differentiating Between Internal and External Succession

3.3.1. The Extended Setting. So far, we have only looked at a situation in which a new manager enters a firm to take over business, i.e., at a situation of external management succession. Yet, in many situations in reality, we have internal succession in management turnover. Especially vacant CEO positions are often filled by internally recruited managers, e.g., by former divisional officers. Moreover, empirical studies have shown differences in post-turnover performance related with

[30]See, e.g., Friedman and Singh (1989); Wiersema (1992); Denis and Denis (1995); Weisbach (1995) or Huson et. al (2004).

the type of succession decision.[31] In the forthcoming sections, we extend our analysis to include situations of internal succession. For that, we use an extension to the basic model introduced above.[32]

We focus on a key difference between internal and external succession in this model extension. Previously, we implicitly assumed that the newly hired manager and the strategic project were not linked in any way. Now, in the case of internal succession, we assume that the new manager has already been working on the project in his former position. Thus, the project outcome is not only depending on the ability of the preceding manager but also on that of the new manager.

An easy example to illustrate this is the following. Suppose the company recently developed a new major product line. In the development process of this product, the head of product development would certainly have played an important role. In the case of CEO succession, in which the global head of product development advances to CEO position, the relationship to this new product line is a different one than that of an external new manager. In particular, a failure of this product line or a cancelation of it would lead to a new – probably negative – assessment of the new manager's ability by the external market.

In order to take this into account, we consider the following model extension. Let the basic scenario be the same as in the basic model. We now assume that the probability of the ongoing project P being a success is linked to both M_{new}'s and M_{pre}'s ability. More precisely, we have a non-negative $q \leq 1$, such that

$$\Pr\left[P = \Pi_{inv}\right] = q \cdot a + (1 - q)a_{pre},$$

with a_{pre} being the ability of the preceding manager M_{pre}. Then, q describes how strongly the new manager's ability is associated with the

[31]For an overview see Kesner and Sebora (1994).

[32]See section 3.2.1.

success of the ongoing project.

This extends the existing model such that the basic model is the special case of $q = 0$. Both the predecessor's and the new manager's ability are their private information. Only their reputations $\hat{a}$ and $\hat{a}_{pre}$ are common beliefs of the owner and the external market at time $t = 1$.

We assume that the basic structure, timing and utilities of the extension stay the same. Therefore, we do not recompute all of the equilibria as in the analysis above. Rather, we focus on describing the essential differences arising from effects of internal succession.

3.3.2. Internal Succession and its Influence on the Divest Decision.

3.3.2.1. *Positive Effects of Internal Succession.* Before we go into describing the equilibria that can be derived from the assumptions above, we want to describe the two effects arising from the link between the new manager and the ongoing project. The first effect is that, when the new manager decides to cancel the ongoing project, the market thinks that the original decision to invest in this project was not confirmed. As a result, it will decrease its beliefs about the new manager's ability as compared to when the old project was not linked to the new manager at all.

The second effect that this extended situation has, is when the manager decides to keep the ongoing project, the project's outcome will allow conclusions about the manager's ability. A project failure will then decrease the manager's reputation whilst a success will lead to a better reputation. Note that the magnitude of these effects depend on the parameter q.

From the owner's point of view, these two effects of internal succession lead to a positive effect. The new manager tends to be more thoughtful about canceling the ongoing project. This alleviates the negative reputation effects from our previous analysis that managers tend to cancel 'too many' projects. The manager now faces a loss in reputation when canceling a project he helped initiating. The following proposition shows the positive effect from internal succession.

Proposition 3.3.1. *Given a situation of internal succession, i.e.,* $q > 0$*, let the degree to which the manager was involved in the ongoing project* P *be not too large, i.e., for small values of* q*. Then the level of* $\frac{\omega_R}{\omega_P}$ *up to which the equilibrium in which both types of managers behave exactly in the owner's best interest is larger than that in case of external succession*[33] *and increasing in* q*.* □

The intuition for this proposition follows our above arguments. The scenario of internal succession has the two effects afore described. Due to these two effects, the equilibrium in which both players behave in the owner's best interest becomes more likely for small values of q. As q gets larger, however, the loss in reputation the manager faces from canceling his own project outweighs the expected increase in reputation from possibly creating a successful project of his own. Therefore, when q is very large, the manager will even keep projects where the accounting signal indicates failure.

In general, for small values of q, the basic equilibrium analysis is very similar to that of the basic model. The results only differ in the exact boundaries in which the equilibria exist. Since we examined this in detail for the basic model, we omit the rest of the equilibrium analysis. In a next step, we will see that internal succession may also have negative effects if the level of involvement, q, gets too large.

3.3.2.2. *Negative Effects of Internal Succession.* The reluctancy to cancel ongoing projects is larger when the manager himself was involved in the project, which he now has to decide upon its cancelation. For large enough values of q the manager refuses to cancel the ongoing project even if the leading indicator s indicates project failure. This is

[33]See proposition 3.2.3 (i).

not in the owner's best interest. Instead of canceling too many projects, managers may be too reluctant[34] to cancel projects:

Proposition 3.3.2. *Given a situation of internal succession, let M_{new} be strongly involved into the ongoing top strategic investment decision, i.e., let q be sufficiently large. If managers care much for their reputation and their initial reputation is high, then an equilibrium exists, in which the manager will keep every project regardless of the signaled project profitability.* □

Besides the two equilibria we just saw, the other equilibria from the basic model can be sustained. Due to the additional link between the ongoing project and the new manager's ability, the manager generally becomes more reluctant to cancel projects. Therefore, threshold levels in the importance of reputation to the manager $\frac{\omega_R}{\omega_P}$ for all equilibria move up. This means that only if the manager has very strong career concerns, he is still willing to cancel projects that have a positive signal, s. Other fundamental results of the basic analysis remain the same.

3.3.3. The Succession Decision. The results regarding internal vs. external succession of the previous section provide a new dimension for the analysis of the owner's hiring decision. Before the owner can decide, which exact manager to hire, he needs to determine which ones to consider, i.e. internal and/or external candidates. The overall performance of the company and especially the signal s should be considered in this decision. Particularly, in situations, where things are going well, the owner has an increased interest that the new manager does not cancel profitable projects.

Our results suggest that internal succession is better in cases of good pre-turnover performance, while external succession should be

[34]The basic mechanism behind this reluctancy to cancel ones own projects is very similar to that in the model of Sliwka (2007). The decision that the manager has to take here is, however, more complex. Not only does he have to correct a wrong decision. He also has to reinvest in his own project where the outcome gives a signal about his own ability.

chosen in situations of bad performance and the need for strategic change. The explanation given in our analysis is that, due to career concerns, external new managers have strong incentives for strategic change, while internal ones have a stronger reluctancy to cancel existing projects. These findings are consistent with empirical research like that of Wiersema (1992) or Huson et al. (2004), which also states that external succession will more likely lead to strategic change and, therefore, better post-turnover performance for poor-performing companies. Due to the complexity and number of determinants involved, empirical results of the last thirty years draw a very ambiguous picture[35]. The results of our analysis, therefore, shed additional light on the existing inconsistent empirical results, by emphasizing the importance of the type of succession (internal or external) for post-turnover performance. We have developed a rationale of career concerns leading to strategic change and with it an explanation why external succession is more likely to lead to strategic change. This may be used for more precise future empirical studies to understand the implications of turnover on company performance.

3.4. Conclusion

Uncertainty of the external market about a manager's ability can lead to a situation, in which a manager actively tries to influence his reputation. A reason can be managers' career concerns. As we have seen, career concerns significantly change managerial behavior – in our case, a manager's invest / divest decisions after executive turnover.

Due to these career concerns a manager may not behave in the owner's best interest. A conflict of interest arises. Misbehavior can take two completely contrary patterns. The manager may either have a tendency towards 'too much' or 'too little' strategic change in the business he takes over, depending on whether he is external or internal. To establish a good reputation, an external manager newly joining

[35] See Kesner and Sebora (1994).

the company may stop profitable projects. This effect is even stronger if his predecessor had a very good reputation. In that case, the manager will have a strong incentive to differentiate himself from his predecessor.

On the other hand, an internal manager might be too involved in existing strategic investment decisions to decide rationally. For this manager, canceling a project means admitting a failure. His market reputation may suffer. An internal manager's interests may, therefore, also not be aligned with those of the owner. He may tend to keep projects even when they are most likely a failure.

Our results have an impact on the existing findings in related literature. We have shown a manager's investment incentives may be different following executive turnover. In addition to the conflicts of interest, which have been studied in a broad stream of existing literature, career concerns may induce further conflicts. These conflicts need to be considered when designing contracts to create robust incentives for a manager. Company owners have to find ways to deal with management that is too eager or too reluctant to cancel existing projects.

We have seen that an executive hiring decision should not only consider a manager's reputation. Rather than that, the owner should consider the company's specific situation in her hiring decision. In situations, like those of financial distress, in which she wants to use management turnover as an instrument for strategic change, an external manager with a good market reputation should be the best choice. When the company has shown a good performance, internal succession may lead to a more stable company development.

Since empirical findings over the last three decades have been highly inconsistent, our findings can only be consistent with parts of the empirical literature. First of all, our analysis shows that career concerns may be one possible explanation for the empirical results of Weisbach

(1995), who found evidence of new managers tending to reverse investments of their predecessors. The possible rationale we provide is that managers do this in order to establish or improve their own reputation. Due to reasons of reputation, this effect should be the strongest, the more uncertainty about the manager's ability there is in the market. Hence, our analysis predicts that the relationship between executive turnover and strategic change should be stronger for younger executives with less experience and market exposure. This is consistent with empirical findings that have tested the influence of age and tenure like those by Grimm and Smith (1991), Wiersema and Bantel (1992) or as discussed by Brickley (2003).

Secondly, our result that positive post-turnover performance is more likely for companies with a poor pre-turnover performance has been shown in existing research like, e.g., by Friedman and Singh (1989). Furthermore, the finding that external succession will raise the probability of strategic change and with it the probability of post-turnover success for weakly performing companies has been shown in empirical studies such as by Wiersema (1992), Denis and Denis (1995) or Huson et al. (2004).

The great number of different studies on the implications of executive turnover over the last years have underlined the importance of this field of research. The inconsistency of the results from these studies, however, demonstrates the complexity of the topic and the large number of underlying determinants. This work contributes to the existing literature by providing a more theoretical understanding of some of the basic mechanisms that determine the outcome. Our findings may be used as a basis for more precise future empirical research. In particular, two of our findings should lead to empirically testable settings and suggestions for their empirical operationalization. First, our prediction that internal succession creates a reluctancy towards strategic change as compared to external succession could be used a hypothesis for empirical testing. Especially, for well-performing companies future empirical findings supporting our results would underline the importance of career concerns as a determinant in this context. To the best of our knowledge, no empirical testing has been done with these exact parameters.

Secondly, the finding that a new manager's incentives for strategic change are increasing in his predecessor's reputation should further be tested. The challenge of testing this prediction would be to isolate the predecessor's reputation without changing other important determinants. Designs of existing empirical research do not focus on this determinant and can, therefore, not be used to verify these predictions. Difficulties to isolate this single effect may suggest an experimental approach. To the best of our knowledge, research on this exact effect does not yet exist.

Rather than the assessment of a manager's ability by the external market, which we examined in this chapter, the focus of our next analysis is how a manager's effort decision is influenced by his own assessment. In the remainder of this work, we assume the manager does not know his own ability yet, but has to learn it as he gains more experience.

CHAPTER 4

Influence of Self-attribution Bias on Effort Incentives

After highlighting the strong influence reputation can have on managerial investment decisions, we want to demonstrate that a manager's own assessment of his ability influences his effort incentives. In the following analysis, we introduce a common human behavioral bias, called self-attribution bias. Self-attribution bias changes how a manager updates the beliefs about his ability. We discuss the changes resulting from this bias on the manager's behavior and derive implications on the choice of performance measures to create effort incentives.

4.1. Relevance of Self-attribution Bias and Overconfidence

When individuals observe the outcome and consequences of their actions, they draw conclusions about their own type and ability. In other words, they learn.[1] Our learning, however, is not always purely rational. Instead, we rather tend to take too much credit for positive outcomes of our work and attribute negative outcomes to external factors such as bad luck[2] – or as Langer and Roth (1975) put it: "Heads I win, tails it's chance".

This phenomenon is called self-attribution bias. Self-attribution bias is closely related to overconfidence. In fact, both theoretical and empirical studies have shown that in several situations self-attribution bias may lead to overconfidence.[3] For example, Billett and Qian (2008)

[1]See Fudenberg and Tirole (1983) and Spence (1981) for early dynamic models with focus on learning.
[2]See Hastorf, Schneider and Polefka (1970); Wolosin, Sherman and Till (1973); Langer and Roth (1975); Miller and Ross (1975) for evidence on self-attribution bias. See Tayler and Brown (1988) for a survey of the literature.
[3]See, e.g., Hilary and Menzly (2006).

provide empirical evidence that the likelihood of an acquisition increases in the performance associated with previous acquisitions. Gervais and Odean (2001) find in a theoretical economic model that traders with a self-attribution bias become overconfident if they were successful in the past.

In this chapter, we analyze the effects of self-attribution bias on a manager's effort incentives and his level of (over)confidence. For this, we use a dynamic discrete multi-period model of moral hazard. A large stream of literature has analyzed effort incentives of hired manager's especially in the context of contract theory.[4] One fundamental result of all theoretical analyses has been that the manager's ability is one of the key determinants in his choice of effort. A high ability manager will be more likely to work harder as his productivity his higher. Especially younger managers, however, do not (or not fully) know their ability and only learn it as they observe the outcome of their decisions. Despite existing strong empirical evidence that learning about one's own ability is usually not rational,[5] existing literature on effort decisions has mostly assumed rational learning. In this work, we will extend existing approaches by analyzing the effects of irrational learning as a result of self-attribution bias.

In the setting of our model, a firm owner hires a manager to operate a company on his behalf. The outcome of the manager's work for the principal is determined by his unknown ability, which is exogenously given, and the unobservable effort chosen by the manager. Since the manager's ability is unknown, both owner and manager can only use the expected ability as basis for their decisions. We assume the manager to be overconfident and the principal to be rational and aware of the manager's bias. Thus, their beliefs about the manager's ability do not coincide, when outcomes are observed and the two players learn.

[4]See section 2.2.2.1 for a discussion of the literature.

[5]See Tayler and Brown (1988) for on overview of the evidence on self-attribution bias.

The goal of our analysis is to compare the behavior of a biased manager to that of a purely rational one from the point of view of the owner. We use a classical moral hazard setting[6] limited to linear compensation contracts with risk neutral principal and agent,[7] to isolate the effects of self-attribution bias.[8] Our modeling of dynamic learning is similar to Gervais and Odean (2001) who look at an economic setting of biased traders.

Our analysis yields the following results. (1) The biased manager's expected effort level is higher than that of a manager in the rational case. The extra effort is due to the fact that, ex ante, the self-attribution bias leads to overconfidence. The more successful a manger is, the higher is his level of overconfidence. Self-attribution bias, thus, may alleviate potential agency costs. (2) On the other hand, when low outputs are observed, self-attribution bias may induce underconfidence and lower levels of effort. This rather counterintuitive result is due to our first result. As the expected effort level increases, the observed signal's[9] quality increases as well. When a low output is observed even though the manager exerted more effort, this higher quality signal reduces the his level of confidence more than in the unbiased case. Therefore, underconfidence is not induced by the modeling of the bias itself but goes back to the moral hazard setting itself. (3) The expected level of overconfidence has it's peak at the beginning of the agent's career and then slowly declines over time. High levels of overconfidence seem to be characteristic especially for young and inexperienced managers. (4) More aggregated performance measures provide better incentives for biased managers than for rational ones. In addition, younger managers may need less performance information to exert a certain effort

[6]This goes back to Holmström (1979).

[7]The model used is a common simplification of the LEN model by Spremann (1987) and Holmström and Milgrom (1987) with a quadratic cost function and risk neutrality. See section 2.2 for a more detailed look on agency theory.

[8]We do not look at optimal compensation contracts, but only analyze, how optimal contracts change in the presence of self-attribution bias.

[9]The output as a signal for the manager's ability.

level than experienced ones. This last result is due to the falling level of overconfidence as managers become more experienced.

This chapter is related and contributes to three streams of the literature. First, a large body of literature analyzes the influence of self-attribution bias and overconfidence on various corporate settings. In finance, many recent publications have investigated effects of overconfidence in the context of different topics such as trading volume and asset pricing.[10] A recent review on behavioral finance is given by Subrahmanyam (2008). For a critical view on behavioral finance see for example Fama (1998).

Furthermore, overconfidence has been investigated in several principal-agent models. Among these are settings of tournaments[11], team effort[12] and signaling games.[13] Most closely related to our research in this stream are, however, those models using a moral hazard setting. De la Rosa (2007), e.g., analyzes the effects of overconfidence on the optimal incentive contract. In contrast to our model, in his setting overconfidence is exogenously given and not a result of self-attribution bias. He finds that there are two conflicting effects of overconfidence on the optimal level of performance based pay. For higher levels of overconfidence his results are mostly in line with our results that due to overconfidence the agent exerts more effort ceteris paribus. De la Rosa, however, does not include dynamic effects of learning.[14] Santos-Pinto (2008) investigates the influence of self-attribution bias on effort in a static single period setting with discrete effort choices. In contrast to our setting,

[10]See Hirshleifer (2001); Daniel, Hirshleifer and Subrahmanyam (2001); Statman, Thorley and Vorkink (2006); Glaser and Weber (2007) and Doukas and Petmezas (2007) for recent research on self-attribution bias and overconfidence in (behavioral) finance.

[11]See Goel and Thakor (2008) or Santos-Pinto (2007) for examples.

[12]As in Gervais and Goldstein (2007).

[13]See Gervais, Heaton and Odean (2003) for an example of a related signaling game.

[14]Adrian and Westerfield (2009) for similar results.

he does not model the biased learning process and its influence on performance measures.

Literature on underconfidence, on the contrary – a phenomenon we find to result from self-attribution bias for unsuccessful managers – is sparse.[15] To the best of our knowledge, self-attribution inducing underconfidence has not been shown in the literature up to now.

Secondly, our research extends the existing literature examining the benefits of using aggregate performance measures to create incentives. Despite the obvious disadvantages of providing less information,[16] aggregate metrics are an integral part of performance evaluation in many different fields. Employees are often rated with a simple 3-5 step rating, which is then often averaged to a single number and used to rank within their peer. Performance in high school and university is summarized in form of GPAs and used throughout job application to signal someone's ability. And even long-term projects a person is responsible for are usually evaluated based on only a small set of previously fixed key performance indicators. Apparently, the disadvantage of reduced levels of information compete with the advantages of a comparable and easily processable measure. Earlier research points out the benefits aggregate performance measures might have. Gigler and Hemmer (2002) show that aggregate measures can reduce an employee's incentives to exploit information for his own well-being. Dewatripont, Jewitt and Tirole (1999) as well as Arya and Mittendorf (2008) examine the benefits of aggregation in the presence of career concerns. They show that due to career concerns it may be beneficial to use more aggregated performance measures. Similar benefits of using coarse information to create incentives for risk averse agents are shown by Feltham, Indjejikian and

[15]See Klayman et al. (1999); Kirchler and Maciejovsky (2002) and Moore and Cain (2007) for results on underconfidence.

[16]The informativeness principle states that any performance measure that contains information about the agent's effort choice should be included in a compensation contract. See Holmström (1979) for the original work and Holmström (1982b) for a multi agent version.

Nanda (2006). We extend the existing literature by providing a new reason for aggregate performance information based on the dynamic levels of overconfidence of a manager with self-attribution bias.

Finally, our work is related to a third branch of research investigating the influence of performance feedback on a manager's incentives to work. Providing performance feedback changes the incentives of a manager[17] to exert effort for his work.[18] In our model, the agent constantly learns, based on the feedback about the quality of his work. We show that the detail level of this feedback changes a biased manager's effort level. An overview of recent developments in the research of performance feedback and goal setting[19] can be found in Latham and Locke (2007).

The remainder of this chapter is organized as follows. In section 2, we will introduce the basic model, isolate the effects self attribution bias has on the agency setting and show how these effects change over time. Section 3 introduces multiple performance measures and examines how providing different levels of performance information is affected by the bias. A conclusion and short prospect on future research is given in section 4.

4.2. Modeling Self-attribution Bias in a Setting of Moral Hazard

4.2.1. The Basic Model.

4.2.1.1. *The Multi-period Moral Hazard Model.* Similar to the basic setting of our last model in chapter 3, we analyze a setting in which a risk-neutral owner O of a firm – called the principal – employs a risk-neutral manager M – called the agent – in a multi-period model

[17] For an analysis of goal setting, when communication is costly see Friedl and Sandner (2009).

[18] See Mohnen and Pokorny (2006) and Mohnen (2008) for theoretical and experimental analyses of how (honest) performance feedback changes an agent's incentives in a signaling game.

[19] See Locke (1996).

with n periods and discrete effort choice.[20] The agent is of ability a, which can be either high or low, i.e., $a \in \{a_H, a_L\}, 0 < a_L < a_H < 1$. We assume that the manager is young with only little experience as an executive. Hence, it makes sense to further assume that the manager's true ability is not (yet) known to any of the two players.

In each period t, the agent's work produces an unobservable output, which is measured by and contracted upon a single performance measure Y_t . The output in a given period t (as well as the performance measure) is determined by the manager's ability a and the level of effort e_t he exerts, $0 \leq e_t < 1$, The effort cannot be observed by the principal. Furthermore, we assume that the output and the related performance measure[21] can take one of two possible values, high or low output, i.e., $Y_t \in \{\Pi_H, 0\}$. Specifically, we have that

$$\Pr\left[Y_t = \Pi_H\right] = a \cdot e_t, \forall_t.$$

We assume that the agent's wage W_t in each period is determined by a linear compensation scheme, which is based solely on the performance measure Y_t, i.e.,

$$W_t = \alpha + \beta Y_t.$$

The agent bears costs for exerting the chosen level of effort e_t. In each period, these costs are given by a convex effort cost function $C(e_t) = \frac{1}{2}ce_t^2$, where c is a constant reflecting the agent's individual level of effort cost. Accordingly, the agent's goal is to maximize his overall utility

$$U = \sum_{t=1}^{n} \left(W_t - C(e_t)\right).^{22}$$

[20]We only look at $n \geq 2$, as we are interested in a multi-period setting.
[21]For reasons of simplicity, from now on we will use output and its related performance measure interchangeably. Until we introduce multiple performance measures in a later section, this inaccuracy does not have any implications on the model or its results.
[22]Since we want to isolate the effects of self-attribution bias and to keep the analysis notationally focused, we assume a discount rate of zero.

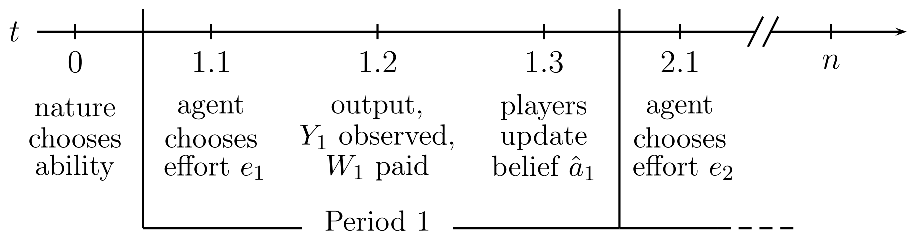

FIGURE 1. Timeline of the basic model in chapter 4.

As the ability a is not known to any of the players, both manager and owner form beliefs about the manager's ability. We assume that manager and owner share a common prior belief $\hat{a}_0$ about the agent's ability at the beginning of the game. These beliefs are then updated by each of the two players, when new information about the agent's ability becomes available at the end of each period. Updated beliefs at the end of each period are denoted by $\hat{a}_t$.[23] The agent chooses his effort at the beginning of period t based on the beliefs he updated at the end of last period, i.e. based on $\hat{a}_{t-1}$. More precisely, given the game's history H_t of all that has happened until period t, $\hat{a}_t$ is defined as

$$\hat{a}_t := E\left[a\,|H_t\right] = \hat{\eta}_t a_H + (1-\hat{\eta}_t)a_L.$$

Note that, in this definition, $\hat{\eta}_t = \Pr\left[a = a_H\,|H_t\right]$ is the probability that, in period t, the manager is of high ability. Figure 1 summarizes the timeline of the basic model.

4.2.1.2. *Essential Mechanisms of Learning.* Before we go deeper into modeling the self-attribution bias of the manager, we will have a closer look at the basic setting and the mechanisms behind the learning process (i.e, the update in beliefs). To make this simpler, we temporarily limit our analysis to a model with only two periods, $t = 1, 2$[24] and investigate the process of updating the beliefs at the end of period 1,

[23] In all of this chapter, we will use a hat above a variable (e.g. $\hat{a}_t$) to indicate that it contains an expected value.

[24] More accurately, it is a three-period model, as we do have natures move in period 0. We will, however, refer to this setting as a two-period model as only two periods are of importance for the analysis.

i.e. 1.3, given the output Y_1.

Both principal and agent share a common prior belief about the manager's ability $\hat{a}_0 = \hat{\eta}_0 a_H + (1 - \hat{\eta}_0) a_L$. Now suppose that the observed output in period 1 is high, i.e., $Y_1 = \Pi_H$. Using Bayes' rule[25], the updated belief of an agent of high ability is given by

$$\begin{aligned}
\hat{\eta}_1|_{\Pi_H} = \Pr\left[a = a_H \,| Y_1 = \Pi_H\right] &= \frac{\hat{\eta}_0 a_H e_1}{\hat{\eta}_0 a_H e_1 + (1 - \hat{\eta}_0) a_L e_1} \\
&= \frac{\hat{\eta}_0 a_H}{\hat{\eta}_0 a_H + (1 - \hat{\eta}_0) a_L} \\
&= \hat{\eta}_0 \frac{a_H}{\hat{a}_0},
\end{aligned}$$

where e_1 is the level of effort chosen by the manager at the beginning of period 1. An important observation for this case of high observed output is that the updated belief does not depend on the chosen effort level – the effort level cancels out. Consequently, the updated belief, when a high output is observed, only depends on the belief of the (single) previous period. This holds for any given period.[26] Furthermore, it is independent of the chosen level of effort. This feature significantly simplifies the analysis, as it eliminates path dependency for the case of high output. Unfortunately, this is not the case when a low output is observed. In that case, we get

$$\begin{aligned}
\hat{\eta}_1|_0 = \Pr\left[a = a_H \,| Y_1 = 0\right] &= \frac{\hat{\eta}_0 \left(1 - a_H e_1\right)}{\hat{\eta}_0 \left(1 - a_H e_1\right) + \left(1 - \hat{\eta}_0\right)\left(1 - a_L e_1\right)} \\
&= \hat{\eta}_0 \frac{1 - a_H e_1}{1 - \hat{a}_0 e_1}.
\end{aligned}$$

As a result, the updated probabilities now depend on the effort levels chosen in previous periods. Beliefs become path dependent in the sense that they are not only a function of the total number of high and

[25]Later on we will use a modified version of Bayes' rule to model self attribution bias.

[26]If the output in period t is high, the updated belief at the end of period t, i.e. $t.3$, will only depend on the belief at the end of period $t - 1$.

low outputs so far but do depend on the exact output pattern[27].

Based on the calculations and considerations we have just made, we can now understand what happens, when a single output is observed. The answer is very intuitive: When the agent observes a high output – i.e., upon a success – he will raise his beliefs about his own ability. In case he observes a failure, he will lower his own beliefs. We get the following result

$$\hat{\eta}_1\,|_0 < \hat{\eta}_0 < \hat{\eta}_1\,|_{\Pi_H}\ , \tag{1}$$

where $\hat{\eta}_1\,|_{Y1}$ is the probability that the agent is of high ability, conditional on the output Y_1.

Since every period has the same basic structure, the update in beliefs is the same for each period. We can, therefore, use the calculated formulas for the general case of $n \geq 2$. Accordingly, at the end of period $t > 0$ we get the general formula for the updated belief

$$\hat{\eta}_i|_{Y_{t-1}} = \begin{cases} \hat{\eta}_{t-1}\frac{a_H}{\hat{a}_{t-1}} & \text{, for } Y_{t-1} = \Pi_H \\ \hat{\eta}_{t-1}\frac{1-a_H e_t}{1-\hat{a}_{t-1}e_t} & \text{, for } Y_{t-1} = 0. \end{cases} \tag{2}$$

From the manager's perspective, when the game begins, he has to choose the level of effort e_1 in period 1.1.[28] Since he wants to maximize his overall expected utility, he will not only look at the current period and choose the optimal effort level for this single isolated period. Instead, he will anticipate future implications of his choice and choose and effort level that induces the overall optimal utility. This is done

[27]Our model differs in this specific feature from that of Gervais and Odean (2001), which analyzes the influence of self-attribution bias on a trader's behavior. The difference is due to the fact that, in our model, by choosing his effort level, the agent changes the probability of a high output.

[28]See figure 1 for the detailed timeline.

using backward induction[29], i.e., the manager will calculate the optimal effort level of the last period, n, conditional on the outputs of the previous periods. This can easily be solved by the first order condition of the last problem. After that, he uses this optimal effort level and the associated expected utility in period n to calculate the optimal effort level in period $n-1$ and so forth, until he gets to the optimal effort level in period 1. At the end of period 1, i.e. in 1.3, the agent updates his belief about his own ability. He then redoes the whole process in period 2 to choose his second period effort.[30]

Note that the focus of this paper, however, is not to solve this problem but to show how the existence of self attribution bias changes the solution. Hence, for us it is sufficient to know that there is a unique solution to the problem. More specifically, we will assume that the optimal effort level in period i for the optimization problem is e_t^*. As a next step, we will now introduce self-attribution bias to our basic model and compare how effort levels and related outputs will change compared to the solution of the original model without self-attribution bias. Accordingly, in this new setting, we will call the optimal level of effort in period i, e_t^{*b}.

4.2.1.3. *Modeling Self-attribution Bias.* We had a closer look at the updates in beliefs, when new information becomes available in terms of the observed output of the manager's work. This update is classically done using Bayes' rule and assumes that the agent updates his beliefs absolutely rationally. However, as we pointed out above, a large stream of research suggests that, in reality, beliefs on one's own ability are not updated in a purely rational manner. In particular, people tend to attribute positive outputs of their work more to their own ability than they do negative outputs. Accordingly, this suggests that when modeling human behavior, like in our case, the purely rational Bayesian

[29]We assume an underlying framework of subgame perfection.

[30]Similar models have been subject of frequent investigation. See, e.g., Mohnen and Pokorny (2006) and Mohnen (2008).

update does not give completely realistic results. Therefore, we will change the way the manager updates the beliefs about his own ability in order to model the self-attribution bias.

Like Gervais and Odean (2001), we will introduce a bias factor $b \geq 1$, where $b = 1$ represents the unbiased rational case. Now, we assume that in the case of a high output, i.e., $Y_i = \Pi_H$, the manager's updated belief at the end of period i will be

$$\hat{\eta}_i^b\,|_{\Pi_H} = \frac{b\hat{\eta}_{i-1}a_H}{b\hat{\eta}_{i-1}a_H + (1-\hat{\eta}_{i-1})a_L}. \tag{3}$$

We further assume that the updated beliefs in case of a low output will be unchanged,[31] i.e., $\hat{\eta}_i^b\,|_0 = \hat{\eta}_i\,|_0$.

Remember that this biased way of updating only applies for the manager and not the owner. This is reasonable as self-attribution bias is only related to assessing one's own ability. Thus, in this model the manager and owner will only share the same prior beliefs and will have different assessments of the manager's ability afterwards: The principal will still use the standard rational Bayesian update. We will now have a closer look at what implications the self-attribution will have.

4.2.2. Levels of Confidence. We want to analyze how self-attribution bias affects the outcomes of the game. Hence, we will compare the decisions made by a purely rational manager to those of a manager with self-attribution bias. To measure the difference between the two, we introduce the notion of the manager's level of confidence. The level of confidence κ_t in period t will be defined as the difference between the probability that the manager is of high ability as seen by a biased manager to that of a rational one. Precisely, let $\sigma_t = (Y_1, \ldots, Y_t) \in$

[31] This is done for ease of calculation and notation. Modeling the bias could have also been done using a second factor smaller than 1 which could have been used to change the update in the low output case. However, just like in Gervais and Odean (2001) this would not have changed the results but only the complexity of the calculations.

$\{\Pi_H, 0\}^t$ be the vector of outputs observed in the game up to period t. Then the level of confidence is defined as

$$\kappa_t = \kappa_t(\sigma_t) := \eta_t^b - \eta_t.$$

From now on we will speak of overconfidence for positive values $\kappa_t > 0$ and of underconfidence (or modesty) for negative ones.[32] This seems reasonable, as a positive value of κ_t means that a biased manager overestimates the probability that he is of high ability. Thus, a positive κ_t means that the manager believes that his ability is higher than a purely rational manager would think. On the contrary, $\kappa_t < 0$ would mean just the opposite – the manager underestimates his ability.

The confidence level κ_t is defined ex post, in the sense that it depends on a fixed history of outputs. This, however, is one important characteristic that makes this definition much more subtle than one might think at first sight: As we will see later in this analysis, the pure existence of the bias will change the effort levels the manager chooses to optimize his utility. But, since the probability of a high output does not only depend on the ability but also on the effort, the ex ante probability of a high output in every period is changed. From an ex ante perspective, confidence will, therefore, take the changed output probabilities due to higher effort into account, while the ex post perspective can only measure the bias given a fixed pattern of past outputs. Notice that this effect is even more important due to the path dependency we get once low outputs are observed. Nevertheless, we will often speak of the ex ante expected level of confidence $\hat{\kappa}_t = E[\kappa_t] = E[\eta_t^b] - E[\eta_t]$ keeping in mind that this captures the further effect of changed output probabilities.

[32] Our definition is closely related to that of Gervais and Odean (2001), as their definition of κ is larger than 1 iff our's is larger than 0. However, we have chosen the definition as a difference of the probabilities rather than a quotient of the expected abilities for reasons of ease in the computations. Note that we do not call this measure overconfidence, as we allow for negative values in confidence.

4.2.3. Basic Implications of Self-attribution Bias. We have now gathered the relevant notation and assumptions to investigate the changes in behavior that self-attribution will induce in this setting. To get a better understanding of what happens in the game, suppose that in period 1 the agent observes a high output $Y_1 = \Pi_H$. At the beginning of the game, principal and agent share the same belief about the agent's ability $\hat{a}_0$. At the end of the period, both manager and owner update their beliefs – the manager in the biased way described above, the owner in the rational unbiased way. The confidence of the agent at the end of the period[33] then is given by

$$\begin{aligned}\kappa_1 &= \hat{\eta}_1^b - \hat{\eta}_1 = \frac{b\hat{\eta}_0 a_H}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0)a_L} - \frac{\hat{\eta}_0 a_H}{\hat{\eta}_0 a_H + (1-\hat{\eta}_0)a_L} \\ &= (b-1)\hat{\eta}_0(1-\hat{\eta}_0)\frac{a_H}{\hat{a}_0}\frac{a_L}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0)a_L} > 0.\end{aligned}$$

What this directly implies is that a high output will always lead to a positive change in the level of confidence and this change is stronger the larger b is. The manager will become overconfident with the first update for the case of a first high output. Furthermore, his overconfidence will continuously grow as he observers more and more high outputs.

Despite these straightforward results for the case of high outputs, the analysis becomes far less trivial when looking at a low output (i.e. a failure). Remember that the bias, as we modeled it, only changes the update in beliefs for high outputs. Therefore, the intuitive idea is that for a single low output the level of confidence will not change.[34]

[33]Be aware that the level of confidence is defined as the difference between a biased and a rational manager and not as the difference between the biased manager and the rational owner. Although, in this very particular case of only one high output, these two definitions coincide, this is not the case in general. The reason for that is that the owner is aware of the bias and anticipates the resulting change in effort level, while the rational manager is not.

[34]In the similar setting of Gervais and Odean (2001) this is the case and a low/negative output does not change the level of confidence. In particular they only get positive levels of confidence, i.e., overconfidence.

This intuition is deceiving, though. The reason for that gets clear when looking at the related update for a single period.

So, suppose that in period 1 a low output is observed this time, i.e., $Y_1 = 0$. Then the level of confidence is

$$\begin{aligned}\kappa_1 &= \hat{\eta}_1^b - \hat{\eta}_1 = \hat{\eta}_0 \frac{1 - a_H e_1^{*b}}{1 - \hat{a}_0 e_1^{*b}} - \hat{\eta}_0 \frac{1 - a_H e_1^*}{1 - \hat{a}_0 e_1^*} \\ &= -\hat{\eta}_0 (e_1^{*b} - e_1^*) \frac{a_H - \hat{a}_0}{(1 - \hat{a}_0 e_1^{*b})(1 - \hat{a}_0 e_1^*)}.\end{aligned}$$

When looking at this term, the first important thing to notice is that it is zero when the biased an the unbiased effort are equal. This means that if the optimal effort level of the agent would not change for a biased agent, the intuition we described above would hold. A negative output would not change the level of confidence. Hence, whether a low output has a negative or positive influence on the level of confidence solely depends on the effort decision. The reason for is the path dependency, we have seen earlier. If the agent chooses a higher (lower) level of effort in the biased case, observing a low output will induce underconfidence (overconfidence).

This consideration of the isolated effect when observing a low output shows that we have to consider the effort choice of the agent in the biased case in more detail. In particular, the most interesting question from the perspective of the principal is: What is the expected change in behavior of a manager with self-attribution bias. The following proposition sheds some light on the situation.

Proposition 4.2.1. *The (ex ante) expected level of effort of a manager with self-attribution bias is always higher than that of a purely rational one, i.e.,*

$$E[e_t^{*b}] > E[e_t^*], \forall_t.$$

□

One of the most straightforward yet important implications of this proposition is that it is the owner who benefits from a biased manager.

Since the expected effort of a manager in the biased case is higher than that of a rational manager, the owner has a higher expected payoff from the manager's work. The reason for this higher expected level of effort is that self-attribution bias will lead to expected overconfidence:

Corollary 4.2.2. *Given the situation that a manager with self-attribution bias is working for the principal, we get the following results.*

(i) *The expected optimal level of effort of the manager* $E[e_t^{*b}]$ *is directly proportional to the expected level of confidence* $\hat{\kappa}_{t-1}$ *at the beginning of period* t*. In particular, the expected level of confidence in each period is positive, i.e. the manager is overconfident and* $\hat{\kappa}_t > 0$*.*

(ii) *Both confidence* $\hat{\kappa}_{t-1}$ *and expected effort level* $E[e_t^{*b}]$ *are increasing in* b*.*

Proof. This a direct result of the proof for proposition 4.2.1, where we showed that $e_t^{*b} > e_i^* \Leftrightarrow \hat{\kappa}_{t-1} > 0$. □

Hence, our model shows that self-attribution bias will (ex ante) lead to overconfidence. This result is in line with earlier research done on this topic.[35] However, another of our results does differ from previous results as we will see next.

Remember, previously it was complicated to determine the effect of a single negative output on the level of confidence. The reason for that was that it depended on the level of effort. With the results of the previous proposition and corollary, we can now finish that analysis. Suppose again that a manager observes a low output in period 1, $Y_1 = 0$. As we have seen above

$$\kappa_1 = -\hat{\eta}_0(e_1^{*b} - e_1^*)\frac{a_H - \hat{a}_0}{(1-\hat{a}_0 e_1^{*b})(1-\hat{a}_0 e_1^*)}.$$

Proposition 4.2.1 states that $e_1^{*b} > e_1^*$. Thus, $(e_1^{*b} - e_1^*)$ is positive and the whole term becomes negative. Hence, a single low output leads to

[35] See for example, Gervais / Odean (2001) and Billett and Qian (2008) for the relationship between self-attribution bias and overconfidence.

underconfidence, i.e., $\kappa_1 < 0$. The rationale behind this is that, due to the bias, the manager will choose a higher level of effort. When he then observes a low output, this signal will be stronger than if he would have chosen a lower effort level. Therefore, compared to the unbiased case in which the manager chooses a lower effort level, he will reduce his beliefs about his ability more strictly than a rational manager. In a nutshell, we have shown that in the case of a single low output in the first period, self-attribution bias will lead to underconfidence. In a more general setting we get the following summarizing result.

Corollary 4.2.3. *When a biased manager observes a low output, i.e., $Y_t = 0$, then his level of confidence is reduced, $\kappa_t < \kappa_{t-1}$. In particular, if he only observes negative outputs he becomes underconfident, i.e., $\kappa_t < 0$.* □

Self attribution bias induces overconfidence when only high output is observed, underconfidence when only low outputs are observed and that, in (ex ante) expected terms, the first effect outweighs the latter. This, as we have seen in proposition 4.2.1, induces a higher effort level of the manager. Thus, it is beneficial from the principal's point of view. The mechanism we have found, may alleviate possible negative agency costs that may arise in related settings. Figure 2 summarizes the two basic effects of self-attribution bias. It also visualizes that the effects of the bias for a high output outweigh that of a low output. In the next section, we will have a closer look at the development of the level of confidence over time.

4.2.4. The Lifecycle of Overconfidence. We have seen how self-attribution bias can induce both under- and overconfidence in a setting of moral hazard. Both effects are a result of the self-attribution learning bias, i.e., the learning process of the manager is not truly rational but follows an altered, more subtle pattern. In the course of his career, a manager will most likely experience a series of successes and failures, which will form and change his beliefs. Moreover, the manager will assess his strengths and weaknesses more and more accurately

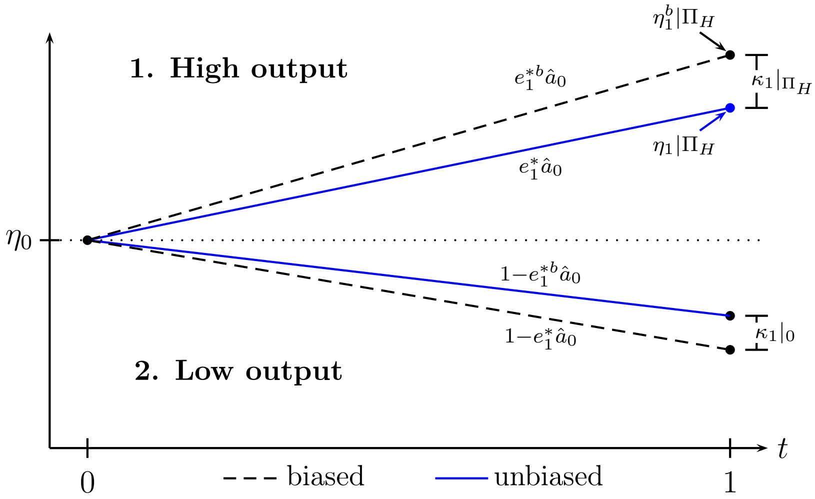

FIGURE 2. Updated beliefs in period 1 conditional on the output for biased and unbiased case. The terms above/below of the lines (e.g. $e_1^{*b}\hat{a}_0$) are the probabilities with which the related case happens.

as he gains in experience. As a result, one would suspect that his beliefs about his ability will become closer and closer to his actual ability.

As it turns out, in the unbiased case, a manager, who does not know his ability, will eventually learn it, as he observes more and more output of his work, i.e., $\lim_{n\to\infty} \hat{a}_n = a$.[36] With self-attribution bias, this is not self-evidently the case as it alters the learning process of the agent. However, for mild biases, i.e., b not too large, we can show that a normal learning behavior can more or less be preserved. More specifically, we have

Proposition 4.2.4. *Assume a biased manager is of ability $a \in \{a_L, a_H\}$ and assesses his own ability to be $\hat{a}_i^b$ at the end of period i (period i.3). Then a b^* exists such that for a bias smaller than b^* (i.e., $b < b^*$), a high ability manager will learn his true ability over time,*

$$\lim_{n\to\infty} \hat{a}_n^b = a_H, \forall_{b<b^*}, a = a_H,$$

[36]We will formally show this at the beginning of the proof for the biased case below.

and a low ability manager will always slightly overestimate his own ability, i.e. there is an ability level $\bar{a}_L$*, with* $a_L < \bar{a}_L < \frac{a_L+a_H}{2}$ *such that*

$$\lim_{n\to\infty} \hat{a}_n^b = \bar{a}_L, \forall_{b<b^*}, a = a_L.$$

□

The proposition says that a biased manager's long-term learning does only differ substantially from that of a rational manager in any of two conditions holds: very high bias levels or a low ability manager. The intuition behind the first is rather straightforward: With larger bias levels, by model design, the bias effects when observing high outputs will be very large. The agent takes too much credit from successes. Therefore, he will raise his beliefs by far more when he observes a high output than he does for a low one. For a milder bias this will only accelerate the learning process when the manager is of high ability. However, if this effect is too strong due to a very strong bias, this may even lead to results in which the agent assesses the probability that he is of high ability to be larger than 1. Since a probability greater than 1 is absolutely non-existent, we will limit our further analysis to bias levels that create sound results.

On the other hand, the rationale behind the effect for low ability managers is very similar. The effects of the bias is larger for small prior beliefs.[37] Hence, if the biased manager already thinks that he is of rather low ability[38], then he will raise his beliefs much more than if he believed he was of very high ability. This explains why a low ability manager will always remain a little overconfident: As the manager's belief falls closer to his true ability, a_L, the effect when a high output is observed grows until it fully compensates the normal expected decrease down to a_L:[39] The growing bias effect dampens the learning of a low ability manager.

[37]The updated belief is a function of $a_H - \hat{a}_i^b$.
[38]Just slightly above a_L.
[39]The limit $\bar{a}_L$ is exactly the level at which the these two effects are equal.

As a next step, we want to look at how the *expected* level of overconfidence develops over time. We have seen in proposition 4.2.1 and its corollaries that during the whole game the manager can be expected to be overconfident. This overconfidence will lead to increased effort and higher expected utility for the principal. As seen in proposition 4.2.4, a manager that has only a mild self-attribution bias will still learn his ability as time passes. A direct consequence of proposition 4.2.4 is that the level of overconfidence for a high ability manager declines over time.

Corollary 4.2.5. *Given a biased agent of high ability. If the bias is smaller than b^* (as given in proposition 4.2.4), the agent's expected level of overconfidence will decline over time:*

$$\lim_{n \to \infty} E[\kappa_n | a = a_H] = 0.$$

PROOF. This directly follows from the proof of proposition 4.2.4. □

If his bias is only small, we have seen in the previous proposition that a manager of high ability will still learn about his true ability eventually. As he observes more and more outputs of his work and new information becomes available, the level of uncertainty about his own ability decreases and therefore the beliefs about his ability will get closer and closer to a_H, i.e. his true ability. In fact, as he takes more credit from observing successes, he will, in that sense, learn faster than a rational manager. Hence, since both the beliefs of a biased and a rational manager converge to a_H, the difference between rational and biased beliefs becomes smaller and smaller, i.e. the level of overconfidence approaches zero.

The ability of the manager, however, is not known to the principal. Yet, both rational and biased managers will (more or less) learn their ability eventually, independent of their ability. This suggests that the expected level of overconfidence should decline over time, independent of the manager's ability. That intuition is true as the following proposition shows.

Proposition 4.2.6. *Given the setting of the previous corollary. If the bias is not too large, i.e.* $b < \underline{b}$ *for some* $\underline{b}$*, a biased manager's expected level of overconfidence will decline over time down to a minimum level of overconfidence* $\underline{\kappa} = \underline{\kappa}(b)$*, i.e.*

$$\lim_{n\to\infty} \hat{\kappa}_n = \underline{\kappa}.$$

□

The development of the agent's expected overconfidence over time is illustrated in figure 3. We have seen that expected overconfidence slowly wears of as the agent gets more and more experienced. As a consequence, overconfidence seems to be characteristic only for younger and inexperienced managers. Our results, in this respect, are very similar to those of Gervais and Odean (2001). Using a model with the same basic underlying framework, they have shown that a trader's level of overconfidence resulting from self-attribution bias also decreases over time. In contrast to our results, in their model overconfidence completely fades away over time, i.e. $\lim_{n\to\infty} \hat{\kappa} = 0$. The reason that in our model overconfidence only decreases to some lower boundary $\underline{\kappa} > 0$ is a contrary effect in our setting of overconfidence directly increasing the manager's effort level and with it the quality of output as a performance signal. The lower boundary $\underline{\kappa}$, therefore, represents the level on which these two effects break even. The basic result of declining overconfidence over time, however, seems to be robust,[40] even in the more complex and path dependent context of our model.

Summarizing the last results, we have seen that the level of overconfidence is a function of the level of information available to the agent.

[40]In the model of Gervais and Odean, the level of overconfidence first rises for a few periods to start falling afterwards. In contrast, in our setting the initial level of overconfidence starts falling right from the beginning when the manager gets more experienced.

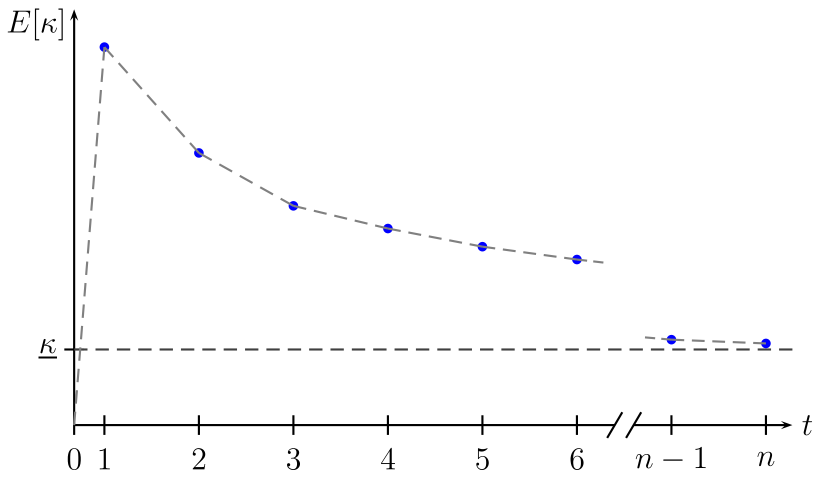

FIGURE 3. Development of the level of confidence over time – initial overconfidence will slowly decline as new information becomes available and the manager gains in experience.

The more information he gets, and the more precise it is, the faster will he lose his overconfidence. Using this result, we will show in the next section that it may be favorable for the principal to provide the agent with a lower level of information.

4.3. Performance Measures for Biased Agents

The choice of the right performance measures for a hired manager have been subject of numerous recent studies. Especially the question of the level and depth of information that should be provided for the manager to get him make the right decisions, has been discussed controversially. Whilst earlier research has always argued that more (detailed) information will lead to more profound and hence better decisions,[41] recent studies have shown that this may not always be true[42] In particular, for various reasons such as career concerns[43] or information overload, it may be that less information and more aggregate

[41]See Holmström (1979) for the informativeness principle.
[42]See for example Feltham and Xie.(1994); Akerlof and Holden (2005) or Autrey et al. (2007) for results on the choice of performance measures in different settings.
[43]See Arya / Mittendorf (2008).

performance measures may have benefits as compared to more information and disaggregate performance measures.

In this section, we want to contribute to this discussion by providing a new argument why less information and more aggregate performance measures may be beneficial for a manager with a learning bias. For this, we will first extend our model to multiple performance measures and transfer the results of the previous section to show the effects of self-attribution bias on the optimal choice of performance measures. As before, we will not show the existence of an optimal compensation contract. Rather than that, we will analyze the influence self-attribution bias has on a given optimal contract with respect to the choice of performance metrics.

4.3.1. Introducing Multiple Measures. So far, we have always spoken of a single performance measure Y_t, which measures a single unobservable output. In reality, the overall perception of a manager's output may be determined by multiple components, i.e., more than one output[44] is important for the agent's work. For example, a business unit's earnings can be further decomposed into a revenue and a cost component. Each of these two components would provide additional information regarding the manager's ability to keep costs under control and sales up. Both measures could be decomposed even further providing more precise information on different aspects of the manager's ability.

In the following analysis, we assume that the agent is still paid and assessed based on his overall measured output Y_t, but that this overall measure is formed by multiple smaller outputs each measured by a less aggregate performance measure. For reasons of simplicity and without loss of generality, we limit our analysis to two performance measures,

[44]Examples may be that the manager is in charge of multiple business units, different projects or has to complete different tasks with multiple outputs.

$X_{1,t}, X_{2,t}$, determining Y_t.

Just like in the basic model, the metrics can be either high or low, i.e., $Y_t, X_{1,t}, X_{2,t} \in \{0, \Pi_H\}$. Y_t is an aggregation of the other two in the sense that it is high (low) if the other two are high (low). We further assume that

$$\Pr[Y_t = \Pi_H] = \Pr[X_{1,t} = \Pi_H] = \Pr[X_{2,t} = \Pi_H] = e_t a,$$

which implies that for indifferent signals $X_{1,t} \neq X_{2,t}$ Y_t takes any of the two values with the same probability.[45]

4.3.2. The Choice of Performance Metrics. We consider the following situation. At the beginning of the game the principal has to decide whether he provides the agent only with the aggregate performance measure Y_t or additionally with the less aggregate $X_{1,t}$ and $X_{2,t}$. As we want to investigate how the learning bias changes the principal's choice, we will compare how the choice of a more aggregate metric in the biased case changes the principal's expected outcome in contrast to the unbiased case. Using this approach, we will isolate the effect the bias has on the setting of selecting the optimal performance measure.[46]

Central for understanding the effect of the bias on the optimal choice in metrics is the following direct corollary of proposition 4.2.6.

Corollary 4.3.1. *The expected level of overconfidence is declining in the amount of performance information available to the agent, i.e., in the number of observed successes and failures.* □

[45]This is just one way to model the aggregation, which has the advantage that most of the previous results can be directly transferred without tedious calculations. Other forms of aggregations like $Y_t = (X_{1,t} \cdot X_{2,t})/\Pi_H$, where only two positive outputs yield a high total outcome or others in which one signal is supposed to be stronger than the other, lead to the same basic results. All these aggregations only differ in what happens for indifferent outcomes.

[46]Suppose that the optimal choice in the unbiased case is to use the disaggregate performance measures as choosing them yields extra expected utility of $\tilde{U}$. Then, if the bias has a positive effect on choosing aggregate performance measures of δ with $\delta > \tilde{U}$, this would mean that in the biased case it would be optimal to select the more aggregate performance measures.

The intuition behind this result is as follows. We have already seen that the level of overconfidence decreases as the agent observes the outcome of his work and learns. Learning, i.e., gathering relevant information about his type, lets him overestimate his own ability less and less. Therefore, when the agent has more performance information available, he learns his true ability faster than he would with less information. Accordingly, his level of overconfidence decreases quicker, as this is linked to his learning.

Using the result of the corollary, understanding the effects of the bias becomes rather intuitive: When the principal chooses to provide the agent with the less aggregate performance information, the agent will learn his true ability quicker than if he only got a single aggregate piece of information. At the same time, his overconfidence will decrease faster in the case with less aggregate information. From the point of view of the principal, this will lead to less expected utility, since we have seen that more overconfidence leads to more expected effort which ultimately leads to higher expected utility. Therefore, compared to choosing the optimal measures for a rational agent, in the biased case the principal has an extra incentive to choose more aggregate performance measures and provide the agent with less information. This result is summarized in the following proposition.

Proposition 4.3.2. *When the principal has to choose the optimal performance measure for the manager, it is always more beneficial to choose aggregate metrics for an agent with self attribution bias, than it would be for a purely rational agent.*

PROOF. The proof is a direct result of the argumentation provided above. □

The same line of thought provides even further insights. We have seen that the agent learns his own ability over time and initial overconfidence slowly declines as part of this learning process. The magnitude of the effect that with more detailed performance information this process is accelerated, however, depends on how far along the game the agent is. Specifically, for an experienced manager who has already observed several successes and failures throughout his working life, the effects we described are far less important than for a young and inexperienced manager. Thus, we have shown that the right choice of performance incentives depends on the manager's level of experience and a set of optimal metrics for a manager at a certain point of time may not be the optimal set as the manager gains in experience: In order to fully utilize their juvenile presumption and commitment, a contract considering the effects of self-attribution bias should give young, inexperienced managers less detailed performance information than experienced ones.[47] More precisely, we get:

Corollary 4.3.3. *For an experienced manager with self attribution bias, the positive effect of choosing a more aggregate performance metric will always be smaller than for an inexperienced manager.* □

This result is especially important in the context of management turnover. When a new manager joins the company, questions of goal setting, performance valuation and feedback mechanisms become very important, as exactly these terms are subject to negotiation and have to be agreed upon. The results above show that the level of experience, a new manager has, should be included in these considerations in the light of self-attribution bias and overconfident managers.

4.4. Conclusion

We have seen that self-attribution bias may alleviate expected agency costs resulting from moral hazard by inducing higher levels of effort for a biased agent. The agent gets overconfident as a result of his biased learning and is, therefore, willing to exert more effort in his work leading to higher expected payoffs for the principal. This effect, however, is contingent on the fact that some high outputs can be expected. For a series of low outputs we have seen that the opposite is true and

[47] Note that we are just looking at effects on a given optimal contract that does not consider self-attribution.

self-attribution bias can lead to underconfidence. The reason for this rather counterintuitive results is that a biased agent will choose higher levels of effort and will therefore expect a higher output level. When he observes a failure now the difference between his expected outcome and the true result will be larger, resulting in a stronger downward correction of his beliefs. From another perspective, the agent's increased effort also increases the quality of the performance signal. This leads to a stronger correction in beliefs when a low output is observed.

All of the results found above have shown that true learning only exists for medium levels of bias. In other words, when the agent takes too much credit from his successes there would no longer be true learning in the sense that only a few successes would be enough to have him constantly belief that he is of high ability. For mild levels of bias we have seen that providing the agent with coarse, more aggregate information will keep him overconfident for a longer time. The positive effects of an overconfident manager for the firm owner may, thus, introduce additional reasons for him to provide only aggregate information.

The results of our analysis can be used as basis for further research. Since most of our results are based on rather subtle mechanisms, especially testing in an experimental context should be suitable in order to verify our findings. In particular, the phenomenon of self-attribution bias inducing underconfidence we found, has, to the best of our knowledge, not been shown in earlier research. It should, therefore, be an interesting result for additional testing. When designing an experiment to prove this it is essential to model the link between the chosen level of effort and the outcome of the agent's work. Remember that our model predicts biased managers to initially exert more effort. If this effort, however, leads to failure they will then reduce their effort level below that of a purely rational manager without self-attribution bias. This is because the failure they observe is a stronger signal about their ability the more effort was initially exerted. Therefore, key challenges of such an experiment design would be a) to create this link between effort and signal quality, and (b) to give incentives for one group to behave in a biased and another in an unbiased way.

Apart from this very specific research question, many other biases and sources of human irrationality, like the one presented in our work, exist. Many of which with a large body of supporting psychology literature. Their influences on various aspects of (corporate) finance has been subject of several publications over the last years. The field of behavioral finance is still growing in popularity. In the field of managerial accounting, research just begins to enter this field. Nevertheless, a lot of topics in managerial accounting, especially those related with performance measurement, goal setting, executive compensation and valuation bear numerous situations in which behavioral aspects may significantly influence the outcome.

The next chapter concludes this work. It will briefly summarize the results of the previous analyses. The chapter will conclude by discussing the limitations of our work and depicting questions for future research.

CHAPTER 5

Conclusions

5.1. Contribution of This Work to the Existing Literature

This work contributes to the existing accounting literature on providing incentives for managers in the following ways. Most fundamentally, we show, how uncertainty about a manager's ability – from both a self-assessment and external reputation point of view – affects the manager's effort and investment incentives. Common behavioral features related to this uncertainty, like self-attribution bias and career concerns, are important determinants for his behavior as his career progresses. In particular, we have shown that a manager's background, his experience and maturity level determine his behavior. These characteristics should, thus, be included when designing compensation contracts and performance measures. Existing literature analyzing investment and effort incentives has mostly neglected the manager's background. Our work shows that considering these aspects may significantly change existing results.

We have analyzed the impact of reputation concerns on a manager's investment decision aftern an executive turnover. This was done using a theoretical career concerns model. When a manager has a strong interest in his market reputation, he may, as a consequence, tend to cancel even profitable projects. Hence, we found that career and reputation concerns can be an explanation for the existing empirical finding that new managers tend to enforce strategic change[1] and often reverse investment decisions of their predecessor.[2] The rationale behind this finding is that creating a possibly successful prestigious project of his

[1]See chapter 3 for a detailed empirical review on these findings.
[2]This is an empirical result of, e.g., Weisbach (1995).

own can potentially increase his reputation more than sticking to the decisions of his predecessor. This effect is even stronger in cases of external succession. Our results in chapter 3 contribute to two streams of the existing literature. Most importantly, they contribute to the accounting literature on creating investment incentives. Instruments designed to create goal congruent incentives should consider effects of career and reputation concerns. More precisely, the owner has to create additional incentives for the manager to keep profitable projects of his predecessor or needs to stipulate their continuation. Furthermore, our results contribute to the literature on executive turnover. By showing that career concerns after a turnover may lead to value destructive management behavior, we provide a new explanation for existing empirical findings on the connection between pre and post-turnover company performance.[3]

On the other hand, we have found that not only uncertainty about ability on the market side is important. A manager's own assessment is also of high importance for the analysis of managerial incentives. In order to show how dependent a manager's behavior is on his learning about his own ability, we have introduced self-attribution bias to a dynamic moral hazard model. We have examined the changes in management incentives and derived its effects to the optimal choice of performance measures. To the best of our knowledge, this is the first time that the influence of self-attribution bias has been studied in a dynamic model with an accounting focus. We find that managerial overconfidence results from self-attribution bias. Due to a manager's overconfidence he exerts more effort than a purely rational one. Hence, self-attribution bias is favorable for the owner and may potentially be an aspect alleviating agency costs. In the dynamic multi-period setting we examined, the level of overconfidence decreases over time and with the experience level the manager gains. Using this fact, we also provide a new aspect to the question how much accounting information should

[3]A more detailed discussion of these results and their contribution to the literature is given in the first and last section of the corresponding chapter.

optimally be provided to the manager. In contrast to earlier results[4], we show that, due to self-attribution bias, providing less (or coarse) information may be beneficial for the owner. Besides the argument of career concerns, which has mainly been used as an explanation for this in existing literature,[5] we show that self-attribution bias provides an additional reason for less aggregated performance measures.

5.2. Limitations of the Analysis

In our analyses we use principal-agent approaches to examine investment and effort incentives in situations of managerial delegation. General critiques on principal-agent models[6], therefore, at least partly apply to this work as well. In particular, such approaches always look at a very idealized setting with complete, free of cost information and very specific underlying assumptions. Therefore, especially the question of how transferable to real life situations such results can be has always been a valid issue. Despite these critiques, we think that the usage of principal-agent models as basis for our analyses is adequate for two reasons. First of all, principal-agent models have been an integral part of current research in business and economics, which have proven to provide clear results and predictions. In particular, as a basis to derive hypotheses for empirical and experimental testing, these theoretical approaches are of high value for modern research. Secondly, especially in this work we have focused on how particular human features and concerns change well established results on managerial incentives. These analyses of the change in incentives, however, is less sensitive to underlying assumptions than other analyses trying to determine a very specific optimum, e.g. an optimal compensation contract. Additionally, we look at very specific human features. Isolating these in an empirical and even an experimental context would be problematic. Results from a theoretical approach like in this work, should provide a

[4]See, e.g. the informativeness principle of Holmström (1979).
[5]See Arya and Mittendorf (2008) for an overview.
[6]For details and a summary on the criticism, see Meinhövel (1999), pp. 107-170. See Grossman and Hart (1983) for mathematical criticism.

better understanding that can reduce these problems.

Apart from that, the analyses in this work bear limitations in two dimensions: completeness of the overall approach and simplifying assumptions of the models. While we consider both sides of uncertainty about management ability and, therefore, try to use a holistic approach with respect to the kind of uncertainty, our analyses of these two sides can still only consider very specific settings. Other settings arising from managerial delegation, for example investment decisions beyond those following executive turnover treated in chapter 3, may show a different level of sensitivity to uncertain ability. Due to the many determinants and overall complexity of managerial incentives, theoretical approaches, like those used in our work, can only address a limited number of aspects. Our results, however, underline the importance of ability assessment and behavioral human features when analyzing investment and effort incentives.

The second limiting dimension is defined by the simplifying assumptions made within the models. Both models only distinguish between two types of managers and only consider a very limited number of possible project outcomes. These simplifications, especially regarding managerial ability, cannot fully capture reality, where managerial ability is a very complex and hard to grasp characteristic. Furthermore, a manager usually has to perform many different tasks and make many decisions virtually simultaneously, which all require different kinds of skills. In reality, however, beliefs about a manager's ability, especially those by the market, are not always very precise. Of the many dimensions of ability, only a few aspects based on the limited performance information available form a manager's reputation. We, therefore, believe that for our specific analyses these simplifications are justified and capture the essential features of ability assessment.

Additionally, the model in chapter 3 only considers a single investment decision following executive turnover. In a multi-period repeated model the participants would learn the manager's true ability over time, reducing potential effects career concerns have on managerial behavior. Beyond that, modeling specific exit options for the manager and job market development would draw a more realistic picture of career concerns and their influence on management behavior. The general mechanism we find that career concerns lead to incentives for new managers to reverse investment decisions of their predecessors is to a certain extent independent of additional levels of complexity or effects that reduce the importance of career concerns. Hence, our results should be fairly robust even in future, more complex settings.

5.3. Possible Model Extensions and Future Research

Possibilities for further research originate from both the findings of our analyses as well as their limitations. Our findings in chapter 3 provide several empirically testable hypotheses. First of all, newly hired external managers are more likely to cancel projects than internal ones, (to some extent) regardless of the project's profitability. Therefore, external succession in situations of bad pre-turnover company performance should correlate with positive post-turnover performance and vice versa. Existing empirical literature[7] on post-turnover performance should be refined to focus on this specific determinant. The same applies for another determinant we found: The market reputation of the predecessor. Just like external succession this raises the likelihood of project cancellation and should therefore have similar effects on company performance.

The results of chapter 4 could be the basis for further experimental testing. We predict that self-attribution bias will lead to higher than rational efforts in a moral hazard setting. An experimental design could

[7] A discussion on existing empirical results is provided in 3.1.

try to isolate and verify this mechanism. In particular, our finding that self-attribution bias can induce underconfidence should be subject to further testing in both the theoretical and experimental context. To the best of our knowledge, this phenomenon has not been found in the existing literature. All the more important is it to model the link between chosen level of effort and outcome of the agent's work. Biased agents initially choose higher levels of effort leading to failure being a stronger signal of low ability. A biased agent will, therefore, correct the belief about his own ability more strongly than a rational one, potentially leading to underconfidence. An experimental design needs to incorporate this specific mechanism of our model. Additionally, our result that providing less performance information in a dynamic multi-period setting should raise the owner's expected overall utility, would be interesting to validate.

The behavioral aspects we used could be applied to related situations of delegated management decision making. Especially the influence of self-attribution bias has not yet been exhaustively examined within the management accounting literature. Just like in the moral hazard setting, self-attribution bias should influence the means to create optimal investment incentives in situations of uncertainty. Finally, extensions to the models of our analyses with relaxed assumptions should test the robustness of our results. A dynamic setting in chapter 3 with multiple periods would analyze the effects of learning to our predictions. Modeling additional exit options would lead to a more realistic framework of executive turnover and could provide even more specific findings. The model in chapter 4 could be extended to include multiple tasks and a refined notion of ability.

This work has shown that managerial incentives do depend on the assessment of ability. When taking investment and effort decisions, managers consider their own ability and possible effects of their behavior on their reputation. Especially, when transferring classical theoretical results to situations in reality, aspects of human behavior should be considered. Further theoretical research introducing more features of human behavior and relaxing existing simplifications should be able to provide a more accurate understanding of managerial incentives in many fields of accounting research.

Appendix

5.4. Proofs of the Results in Chapter 3

PROOF OF PROPOSITION 3.2.1. (i) As defined in the section before, let $\delta \in \{K, C\}$ be the manager's decision regarding the (old) ongoing project. We then have

(4) $$\Delta\pi_{inv} = E\left[\pi_{inv}\,|\delta = C\right] - E\left[\pi_{inv}\,|\delta = K\right]$$

The expected payoffs, if everything is left as it is, are only determined by the quality of the signal s. Since in the case the manager decides to keep the project, the probability that the project is a success is exactly σ, the expected payoff of the project is

$$E\left[\pi_L^O\,|\delta = K\right] = \begin{cases} \sigma \cdot \Pi_{inv} & \text{, for } s = \Pi_{inv} \\ (1-\sigma) \cdot \Pi_{inv} & \text{, for } sa = F. \end{cases}$$

By definition, this yields to

(5) $$E\left[\pi_{inv}\,|\delta = K\right] =$$

$$\alpha \cdot E\left[\pi_L^O\,|\delta = K\right] = \begin{cases} \omega_P \cdot \sigma & \text{, for } s = \Pi_{inv} \\ \omega_P \cdot (1-\sigma) & \text{, for } s = 0. \end{cases}$$

The expected payoff when the project is canceled, on the other hand, is fully determined by the manager's own ability a. Accordingly, we get

(6) $$E\left[\pi_{inv}\,|\delta = C\right] = \omega_P \cdot a.$$

Putting (5) and (6) according to (4) together, we get

$$E\left[\Delta\pi_{inv}\right] = \begin{cases} \omega_P \cdot (a-\sigma) & \text{, for } s = \Pi_{inv} \\ \omega_P \cdot (a-(1-\sigma)) & \text{, for } s = 0 \end{cases}$$

and, hence, the proof of the claim.

(ii) We have that $\frac{\partial \Delta\pi_{inv}}{\partial a} = \omega_P > 0$. In other words, the difference $\Delta\pi_{inv}$ is strictly increasing in the manager's ability a, which concludes the proof. Note that we have that $a < \sigma$, which yields that $\Delta\pi_{inv} < 0$ for a successful project and > 0 for a failure ($s = 0$).

□

Proof of lemma 3.2.2. It suffices to show that for any given project, the overall utility for a good manager to cancel (instead of keep) a project are at least as much as that for a low ability manager.

First, recall that we have defined $\tilde{a}|_S$ as the manager's ex ante expected reputation at the end of the game if he decides to cancel the project and it turns out to be a success.[8]

Now suppose that an equilibrium exists, in which a manager of low ability cancels a given project and a manager of high ability does not. Then the expected reputations $\tilde{a}|_S$ and $\tilde{a}|_F$ at the end of the game after a cancelation are the same for both types. This is because the market does not know the manager's type. Furthermore, we have already seen that $\tilde{a}|_S > \tilde{a}|_F$. As the expected reputation utility is only weighted by the manager's ability, it is higher for a high ability manager.

On the other hand, by proposition 3.2.1, expected prospects from project success when canceling are also higher for a manager of high ability. Therefore, a manager of high ability would have higher total payoff when canceling than a manager of low ability. Hence, under the assumption that it is worth for the low ability manager to cancel the project, it would also be worth canceling for the high ability manager.

[8] $\tilde{a}|_F$ is defined analogously for the case that the new project fails.

As a consequence, in equilibrium it is never the case that only a manager of low ability cancels a project while a high ability manager would not. □

Proof of proposition 3.2.3. (i) Suppose an equilibrium exists where both types of managers only cancel the ongoing project if the profitability signal s indicates a project failure. Then, when the market observes no cancelation of the project, it can assume that there was no cancelation necessary, i.e., $s = \Pi_{inv}$. Since the success of the ongoing project is not related to the ability of the newly hired manager when he keeps the project, the market does not change its beliefs about the new manager's ability. The reputation remains unchanged and the reputation utility for the manager, in case he does not cancel, is just $\omega_R \cdot \hat{a}$.

When the market observes a cancelation, on the other hand, it can conclude that a cancelation was necessary. The updated reputation of the manager will, hence, solely depend on the success of his newly initiated project $\tilde{P}$.

The equilibrium that both managers will only cancel if necessary will, consequently, be achieved when both players have no incentives to cancel successful projects. We have already seen that a manager of high ability has stronger incentives to cancel a project. This, therefore, narrows it down to the condition that a manager of high ability will no longer have an incentive to cancel a successful project. In other words,

(7) $$E\left[\Delta\pi_{rep}(a_H) + \Delta\pi_{inv}(a_H)\right] \leq 0.$$

Whilst the expected value of $\Delta\pi_{inv}$ can be easily determined according to proposition 3.2.1, we will focus on determining the expected change in reputation utility from canceling in the following analysis.

First, note that at the time the manager has to make his cancelation decision, his expected reputation at the end of the game when canceling the project is given by

$$\tilde{a} := a\tilde{a}|_S + (1-a)\,\tilde{a}|_F. \tag{8}$$

We have

$$E\left[\Delta\pi_{rep}\right] = \omega_P \cdot (\tilde{a} - \hat{a})\,. \tag{9}$$

Hence, we have to determine $\tilde{a}|_S$ and $\tilde{a}|_F$. Since these are reputation values, we have

$$\tilde{a}|_S = \tilde{\eta}|_S \cdot a_H + (1-\tilde{\eta}|_S) \cdot a_L$$
$$\tilde{a}|_F = \tilde{\eta}|_F \cdot a_H + (1-\tilde{\eta}|_F) \cdot a_L.$$

According to the above explanation, we get

$$\begin{aligned}\tilde{\eta}|_S &= \Pr\left[a = a_H \,\middle|\, \tilde{P} = S\right] \\ &= \frac{\Pr\left[a = a_H \wedge \tilde{P} = S\right]}{\Pr\left[\tilde{P} = S\right]} \\ &= \frac{\eta \cdot a_H}{\hat{a}} = \eta\frac{a_H}{\eta}.\end{aligned}$$

Analogously, we get

$$\begin{aligned}\tilde{\eta}|_F &= \Pr\left[a = a_H \,\middle|\, \tilde{P} = F\right] \\ &= \frac{\eta \cdot (1-a_H)}{(1-\hat{a}} = \eta\frac{1-a_H}{1-\eta}.\end{aligned}$$

Using this to calculate $\tilde{a}$ according to (8), we get

$$\begin{aligned}
\tilde{a}(a) &= a\left[\tilde{\eta}|_S \cdot a_H + (1-\tilde{\eta}|_S)\cdot a_L\right] + (1-a)\left[\tilde{\eta}|_F \cdot a_H + (1-\tilde{\eta}|_F)\cdot a_L\right] \\
&= a\left[\eta\frac{a_H}{\eta}\cdot a_H + \left(1-\eta\frac{a_H}{\eta}\right)\cdot a_L\right] \\
&+ (1-a)\left[\eta\frac{1-a_H}{1-\eta}\cdot a_H + \left(1-\eta\frac{1-a_H}{1-\eta}\right)\cdot a_L\right] \\
&= a\cdot(a_H-a_L)\cdot\eta\left(\frac{a_H}{\hat{a}} - \frac{1-a_H}{1-\hat{a}}\right) + \eta\cdot\frac{1-a_H}{1-\hat{a}}\cdot(a_H-a_L) + a_L.
\end{aligned}$$

When we now substitute $\eta = \frac{\hat{a}-a_L}{a_H-a_L}$, this yields to

$$\begin{aligned}
\tilde{a}(a) &= a\cdot(\hat{a}-a_L)\left(\frac{a_H}{\hat{a}} - \frac{1-a_H}{1-\hat{a}}\right) + (\hat{a}-a_L)\cdot\frac{1-a_H}{1-\hat{a}} + a_L \\
&= (\hat{a}-a_L)\left[\frac{a(a_H-\hat{a})}{\hat{a}(1-\hat{a})} + \frac{1-a_H}{1-\hat{a}}\right] + a_L \\
&= (\hat{a}-a_L)\left[\frac{a(a_H-\hat{a}) + \hat{a}(1-a_H)}{\hat{a}(1-\hat{a})}\right] + a_L
\end{aligned}$$

$$= (\hat{a}-a_L)\cdot\left(\frac{aa_H - a\hat{a} + \hat{a} - \hat{a}a_H}{\hat{a}(1-\hat{a})}\right) + a_L. \tag{10}$$

Putting the results from (10) into (9), we can calculate the change in utility from reputation:

$$\begin{aligned}
E\left[\Delta\pi_{rep}\right](a) &= \omega_R\cdot(\tilde{a}(a)-\hat{a}) \\
&= \omega_R\cdot\left[(\hat{a}-a_L)\cdot\left(\frac{aa_H - a\hat{a} + \hat{a} - \hat{a}a_H}{\hat{a}(1-\hat{a})}\right) - (\hat{a}-a_L)\right] \\
&= \omega_R\cdot\left[(\hat{a}-a_L)\cdot\left(\frac{aa_H - a\hat{a} + \hat{a} - \hat{a}a_H}{\hat{a}(1-\hat{a})} - 1\right)\right].
\end{aligned}$$

According to (7), we look at the utility of a high ability manager and get

$$\begin{aligned}
E\left[\Delta\pi_{rep}\right](a_H) &= \omega_R\cdot\left[(\hat{a}-a_L)\cdot\left(\frac{a_H^2 - 2a_H\hat{a} + \hat{a}}{\hat{a}(1-\hat{a})} - 1\right)\right] \\
&= \omega_R\cdot\left[(\hat{a}-a_L)\cdot\left(\frac{\hat{a}_2 - 2a_H\hat{a} + a_H^2}{\hat{a}(1-\hat{a})} - 1\right)\right]
\end{aligned}$$

(11)
$$= \frac{\omega_R (\hat{a} - a_L)(\hat{a} - a_H)^2}{\hat{a}(1-\hat{a})}.$$

We can then put the result from (11) plus what we know about the change in project payoff from proposition 3.2.1 into the equation of (7) to get a condition under which the equilibrium exists.[9]

$$\begin{aligned} & E\left[\Delta\pi_{rep}(a_H) + \Delta\pi_{inv}(a_H)\right] && \leq 0 \\ \Leftrightarrow\quad & \omega_R \tfrac{(\hat{a}-a_L)(\hat{a}-a_H)^2}{\hat{a}(1-\hat{a})} + \omega_P (a_H - \sigma) && \leq 0 \end{aligned}$$

(12)
$$\Leftrightarrow \quad \tfrac{\omega_R}{\omega_P} \leq \frac{(a_H - \sigma)\,\hat{a}(1-\hat{a})}{(\hat{a} - a_L)(\hat{a} - a_H)^2}.$$

Hence, for small values of $\frac{\omega_R}{\omega_P}$, which fulfill (12), an equilibrium exists, in which both players behave exactly in the owner's best interest and cancel only unprofitable projects.

(ii) Now suppose there exists an equilibrium, in which both types of players cancel any project regardless of the internal accounting signal s. Since we have already seen that managers of high ability are more likely to cancel than managers of low ability, when the market observes a player not canceling a project, it can assume that the manager is of low ability. Consequently, the reputation utility in this case can only be $\omega_R a_L$. The equilibrium can only exist, if both players are willing to cancel profitable projects. Using, again, the fact that managers of high ability are more likely to cancel than managers of low ability, $(0 \geq \Delta\pi_{inv}(a_H) \geq \Delta\pi_{inv}(a_L))$, we get that the equilibrium exists, under the condition that canceling a profitable project pays off for a manager of low ability. Hence, the following condition needs to be fulfilled

(13)
$$\Delta\Pi_R(a_L) + \Delta\pi_{inv}(a_L) \geq 0.$$

[9]And canceling profitable projects does not pay off for a high ability manager.

Note that just as (i), this is a pooling equilibrium. The update of the manager's reputation, if he decides to cancel, only depends on the success of the project. Accordingly, just like in (i) equation (10), we get that

$$\tilde{a}(a) = (\hat{a} - a_L) \cdot \left(\frac{aa_H - a\hat{a} + \hat{a} - \hat{a}a_H}{\hat{a}(1-\hat{a})} \right) + a_L \tag{14}$$

and with the result that the reputation utility from not canceling is $\omega_R a_L$, we further get that

$$\begin{aligned} E\left[\Delta\pi_{rep}\right](a) &= \omega_R \cdot (\tilde{a}(a) - a_L) \\ &= \omega_R \cdot \left[(\hat{a} - a_L) \cdot \frac{aa_H - a\hat{a} + \hat{a} - \hat{a}a_H}{\hat{a}(1-\hat{a})} \right]. \end{aligned}$$

In particular, for a low ability manager we have

$$E\left[\Delta\pi_{rep}\right](a_L) = \omega_R \cdot \frac{(1 - a_H - a_L)(\hat{a} - a_L)\left(\hat{a} + \frac{a_L a_H}{1 - a_H - a_L}\right)}{\hat{a}(1-\hat{a})}. \tag{15}$$

Putting the result from (15) into (13), the equilibrium exists if

$$\begin{aligned} & \Delta\Pi_R(a_L) + \Delta\pi_{inv}(a_L) && \geq 0 \\ \Leftrightarrow \quad & \omega_R \cdot \frac{(1-a_H-a_L)(\hat{a}-a_L)\left(\hat{a}+\frac{a_L a_H}{1-a_H-a_L}\right)}{\hat{a}(1-\hat{a})} + \omega_P(a_L - \sigma) && \geq 0 \\ \Leftrightarrow \quad & \tfrac{\omega_R}{\omega_P} \geq \frac{(a_L - \sigma)\hat{a}(1-\hat{a})}{(1 - a_H - a_L)(\hat{a} - a_L)\left(\hat{a} + \frac{a_L a_H}{1 - a_H - a_L}\right)}. \end{aligned}$$

□

Proof of proposition 3.2.4. (i) Suppose the equilibrium exists, in which a manager of high ability will cancel any project disregarding the signal s and a manager of low ability only cancels unprofitable projects ($s = 0$). When the market then observes a manager, who does not cancel a project, it can assume that the manager is of low ability. This directly implies that the reputation utility when he decides not to cancel turns out to be

$$\pi_{rep} = \omega_R \cdot a_L. \tag{16}$$

If the manager, however, decides to cancel the project, the market thinks that it was either a manager of high ability or it was a low ability manager who canceled an unprofitable project. When using the notation of the previous proposition, this yields to

$$\begin{aligned}
\tilde{\eta}|_S &= \Pr\left[a = a_H \,|(a = a_H \vee (a = a_L \wedge s = 0)) \wedge P = S\right] \\
&= \Pr\left[a = a_H \,|(a = a_H \wedge P = S) \vee (a = a_L \wedge s = 0 \wedge P = S)\right] \\
&= \frac{\Pr\left[a = a_H \wedge ((a = a_H \wedge P = S) \vee (a = a_L \wedge s = 0 \wedge P = S))\right]}{\Pr\left[(a = a_H \wedge P = S) \vee (a = a_L \wedge s = 0 \wedge P = S)\right]} \\
&= \frac{\Pr\left[a = a_H \wedge P = S\right]}{\Pr\left[(a = a_H \wedge P = S) \vee (a = a_L \wedge s = 0 \wedge P = S)\right]}.
\end{aligned}$$

The probability that $s = 0$ does not depend on the newly hired manager's ability or reputation but only that of his predecessor. Let d_F be the probability that the signal s indicates a failure, i.e. $s = 0$. Then we have that $d_F = (1 - \hat{a}_{pre}) \cdot \sigma + \hat{a}_{pre} \cdot (1 - \sigma)$.

Recall that $\hat{a}_{pre}$ is the reputation of the preceding manager and notice that $d_F < \frac{1}{2}$ and declining in the preceding manager's reputation. Using this notation, we get

$$\tilde{\eta}|_S = \frac{\eta \cdot a_H}{\eta \cdot a_H + (1 - \eta) \cdot d_F \cdot a_L} \tag{17}$$

and accordingly

$$\tilde{\eta}|_F = \frac{\eta \cdot (1 - a_H)}{\eta \cdot (1 - a_H) + (1 - \eta) \cdot d_F \cdot (1 - a_L)}. \tag{18}$$

The ex ante expected reputation $\tilde{a}$ of the manager at the end of the game is

$$\begin{aligned}
\tilde{a}(a) &= a \cdot \tilde{a}|_S + (1-a) \cdot \tilde{a}|_F \\
&= a \cdot [\tilde{\eta}|_S a_H + (1-\tilde{\eta}|_S) a_L] + (1-a) \cdot [\tilde{\eta}|_F a_H + (1-\tilde{\eta}|_F) a_L] \\
&= (a_H - a_L) \cdot [a\tilde{\eta}|_S + (1-a)\tilde{\eta}|_F] + a_L.
\end{aligned}$$

Using the expected utility *when not canceling* from (16), for the expected change in reputation utility *from canceling* a project we get the following

$$\begin{aligned}
E\left[\Delta\pi_{rep}\right](a) &= \omega_R \cdot (a_H - a_L) \cdot [a\tilde{\eta}|_S + (1-a)\tilde{\eta}|_F] \\
&= \omega_R \cdot \left[(a_H - a_L) \cdot \left(\frac{a\eta \cdot a_H}{\eta \cdot a_H + (1-\eta) \cdot d_F \cdot a_L}\right.\right. \\
&\quad \left.\left. + \frac{(1-a)\eta \cdot (1-a_H)}{\eta \cdot (1-a_H) + (1-\eta) \cdot d_F \cdot (1-a_L)}\right)\right].
\end{aligned}$$

In terms of $\hat{a}$, i.e., using $\eta = \frac{\hat{a}-a_L}{a_H-a_L}$, we have

$$\begin{aligned}
E\left[\Delta\pi_{rep}\right](a) &= \omega_R (a_H - a_L)(\hat{a} - a_L) \left[\left(\frac{a a_H}{(\hat{a}-a_L)a_H + d_F a_L (a_H - \hat{a})}\right.\right. \\
&\quad \left.\left. + \frac{(1-a)(1-a_H)}{(\hat{a}-a_L)(1-a_H) + d_F(1-a_L)(a_H-\hat{a})}\right)\right].
\end{aligned}$$

For the described equilibrium to exist, two conditions have to be fulfilled:

First, the importance of reputation needs to be high enough to be an incentive for a high ability manager to cancel profitable projects. And second, the importance of reputation has to be below the level at which it would also pay off for a manager of low ability to cancel profitable projects. In mathematical terms, the two conditions are

$$E\left[\Delta\pi_{rep}(a_H) + \pi_{inv}(a_H)\right] \geq 0, \tag{19}$$

$$E\left[\Delta\pi_{rep}(a_L) + \pi_{inv}(a_L)\right] x \leq 0. \tag{20}$$

Using all the information we have already gathered, we get the following two conditions

$$\frac{\omega_R}{\omega_P} \geq \frac{(\sigma - a_H)}{(\hat{a} - a_L)(a_H - a_L)} \cdot \left[\frac{a_H^2}{(\hat{a} - a_L)a_H + d_F a_L(a_H - \hat{a})} + \frac{(1 - a_H)^2}{(\hat{a} - a_L)(1 - a_H) + d_F(1 - a_L)(a_H - \hat{a})}\right]^{-1} =: \Phi_1$$

and

$$\frac{\omega_R}{\omega_P} \leq \frac{(\sigma - a_L)}{(\hat{a} - a_L)(a_H - a_L)} \cdot \left[\frac{a_L a_H}{(\hat{a} - a_L)a_H + d_F a_L(a_H - \hat{a})} + \frac{(1 - a_L)(1 - a_H)}{(\hat{a} - a_L)(1 - a_H) + d_F(1 - a_L)(a_H - \hat{a})}\right]^{-1} =: \Phi_2.$$

The equilibrium exists, for intermediate values of $\frac{\omega_R}{\omega_P}$ which fulfill these two conditions.

(ii) First, note that the criterium depends on the probability that the signal indicates a failure[10]. This probability, depends on the accuracy of the signal σ and the true profitability of the project. The latter is determined by the ability of the preceding manager, since the project's initiator ι was the preceding manager. The only usable information about the predecessor is his reputation $\hat{a}_{pre}$. The reputation is the market's assessment of his ability. Accordingly, the criterium does depend on the predecessor's reputation.

Hence, in a first step, we have a closer look at $\frac{\partial}{\partial d_F}\Phi_i, i = 1, 2$. Plain algebra shows that

$$\frac{\partial}{\partial d_F}\Phi_i \geq 0. \tag{21}$$

Now, since we have $d_F = (1 - \hat{a}_{pre})\sigma + \hat{a}_{pre}(1 - \sigma)$, we get that

$$\frac{\partial d_F}{\partial \hat{a}_{pre}} = 1 - 2\sigma < 0,$$

i.e., the probability of a failure signal is smaller for predecessors with a good reputation. This and (21) then yields

[10]As perceived by the external market

to

$$\frac{\partial}{\partial \hat{a}_{pre}} \Phi_i \leq 0. \tag{22}$$

and, thus, the first claim.

The second claim that the range in which the equilibrium exists is decreasing for increased reputation $\hat{a}_{pre}$, is equivalent to proving

$$\frac{\partial}{\partial \hat{a}_{pre}} (\Phi_2 - \Phi_1) \leq 0.$$

This is a result of plain algebra.

□

Proof of proposition 3.2.5. (i) Let $\xi_0 = \frac{\omega_R}{\omega_P}$ be chosen such that there exists an $\breve{r}$, which is the single solution to the associated equality of the equilibrium in proposition 3.2.3 (*ii*), i.e.,

$$\xi_0 = \frac{(a_L - \sigma)\breve{r}(1 - \breve{r})}{(1 - a_H - a_L)(\breve{r} - a_L)\left(\breve{r} + \frac{a_L a_H}{1 - a_H - a_L}\right)},$$

and that

$$\xi_0 < \frac{(a_H - \sigma)\,\hat{a}(1 - \hat{a})}{(\hat{a} - a_L)\,(\hat{a} - a_H)^2}, \forall_{\hat{a}}.$$

Since the right side of this equality is strictly decreasing in $\hat{a}$ (as seen above), for medium values of ξ_0, $\breve{r}$ exists and is unique.

By construction, we have that for every $\hat{a} > \breve{r}$ the equilibrium, in which both managers cancel every project, exists. On the other hand, there is an $a < \breve{r}$ such that for every $\hat{a}$ with $a < \hat{a} < \breve{r}$ the only equilibrium that exists is that, in which both managers only cancel bad projects.

Now, when the project is performing well and the expected profit of the project in case of success is very large, it is optimal for the owner to choose a candidate with reputation $\hat{a}$ with $a < r < \breve{r}$. The owner chooses this candidate in order to reduce the risk of the new manager canceling the project[11] – in case there is no other way to detain the manager from canceling. This is the case, when expected prospects from reducing this risk, outweigh expected possible gains that the optimal candidate would achieve as operational utility π_{op}.

(ii) In the exact same case, when there are means to prevent the manager from canceling, the above considerations show that it is optimal for the owner to do so.

□

PROOF OF PROPOSITION 3.3.1. We have to show that the level up to which the equilibrium exists is higher than that in the case of external succession.[12] Recall that according to the analysis in proposition 3.2.3, this equilibrium exists as long as a high ability manager will not cancel profitable projects. As the (monetary) project utility from canceling compared to keeping a project, i.e. $\Delta\pi_{inv}$, is not affected by internal or external succession, it is enough to show that $\Delta\pi_{rep}$ is decreasing for growing values of q. That is, because, in this case, it becomes less attractive for a high ability manager to cancel a good project. Thus, only at higher values of $\frac{\omega_R}{\omega_P}$ he would leave the given equilibrium path.

The following analysis needs a lot of notation, to distinguish the different possible settings. We try to stick to the notation of proposition 3.2.3 as close as possible. Let $q > 0$ and $\tilde{a}$ be the ex ante expected reputation the manager anticipates to have at the end of the game

[11] Since the probability of canceling is increasing in the new manager's reputation.
[12] As in proposition 3.2.3.

when he decided to cancel. Further, let $\tilde{a}|_S, \tilde{a}|_F, \tilde{\eta}|_S$ and $\tilde{\eta}|_F$ be defined according to the previous proposition in the cases in which $\tilde{P}$ is a success (or a failure, respectively). Analogously, define for $\tilde{a}$ and all associated notation, $\tilde{a}|_0$ to be $\tilde{a}$ in the case that $q = 0$. Finally, let $\breve{r}$ and all associated notation be defined for the case that the manager decides to keep the project ($\partial = K$).

Recall that we already said that it is enough to show that $\Delta\pi_{rep}$ is decreasing for growing values of q. $\Delta\pi_{rep}$ is the difference between the expected utility from reputation after canceling and that after keeping the project, we will have a look at these expected utilities.

Suppose that the equilibrium in which both types of managers only cancel a project if the signal indicates a bad project. Then, when the market observes a manager who does not cancel the project, it can assume that there was no cancelation necessary, i.e., $s = \Pi_{inv}$. Now, the difference between the case where we have that $q > 0$ and the prior case of $q = 0$ is that this fact will allow the market to update its beliefs about the manager's ability. More specific, the expected utility when the market observes no cancelation is

$$\begin{aligned} E\left[\pi_{rep}\left|\partial = K\right.\right] &= E\left[\pi_{rep}\left|s = \Pi_{inv}\right.\right] \\ &= \omega_R \left(\Pr\left[a = a_H \left|s = \Pi_{inv}\right.\right] a_H \right. \\ &\quad \left. + \left(1 - \Pr\left[a = a_H \left|s = \Pi_{inv}\right.\right]\right) a_L \right) \end{aligned}$$

The probability that $a = a_H$ in this setting of information is then given by

$$\begin{aligned} \Pr\left[a = a_H \left|s = \Pi_{inv}\right.\right] &= \frac{\Pr\left[a = a_H \wedge s = \Pi_{inv}\right]}{\Pr\left[s = \Pi_{inv}\right]} \\ &= \eta \frac{d_S(a_H)}{d_S(\hat{a})}, \end{aligned}$$

where $d_S(a_H)$ is the probability that the signal s indicates future success ($s = \Pi_{inv}$).

To understand this in detail, we have to look at the probability d_S. This probability does depend on q, the ability of M_{new} and the reputation of the predecessor M_{pre}. It is given by

$$d_S(a) = \sigma\left(qa + (1-q)\hat{a}_{pre}\right) + (1-\sigma)\left(1 - (qa + (1-q)\hat{a}_{pre})\right). \tag{23}$$

Accordingly, the probability that the signal is indicating future failure $s = 0$ is given by

$$d_F(a) = \sigma\left(1 - (qa + (1-q)\hat{a}_{pre})\right) + (1-\sigma)\left(qa + (1-q)\hat{a}_{pre}\right). \tag{24}$$

Note that d_S is increasing for larger values of a whilst $d_F = 1 - d_S$ is decreasing. Therefore, we get that

$$E\left[\pi_{rep}\,|\partial = K\right] \quad = \omega_R \cdot \breve{r} = \omega_R\left(\frac{d_S(a_H)}{d_S(\hat{a})}\breve{r}|_0 + \left(1 - \frac{d_S(a_H)}{d_S(\hat{a})}\right)a_L\right).$$

This is larger than the corresponding utility the manager would expect in case $q = 0$ as we can see in the following.

$$\begin{aligned}
& E\left[\pi_{rep}\,|\partial = K\right]|_q && > E\left[\pi_{rep}\,|\partial = K\right]|_0 \\
\Leftrightarrow\quad & \breve{r}|_q && > \breve{r}|_0 \\
\Leftrightarrow\quad & \tfrac{d_S(a_H)}{d_S(\hat{a})}\breve{r}|_0 + \left(1 - \tfrac{d_S(a_H)}{d_S(\hat{a})}\right)a_L && > \breve{r}|_0 \\
\Leftrightarrow\quad & \left(1 - \tfrac{d_S(a_H)}{d_S(\hat{a})}\right)a_L && > \left(1 - \frac{d_S(a_H)}{d_S(\hat{a})}\right)\breve{r}|_0
\end{aligned}$$

$$\Leftrightarrow a_L < \breve{r}|_0, \tag{25}$$

That, however, is true as long as there is uncertainty about the manager's ability in the market.

Thus, we have seen that the reputation when a manager decides to keep a project for $q > 0$ is larger than that for $q = 0$. Hence, as the manager was involved in the project, in a situation of internal succession, the decision not to cancel the project will result in a reputation gain.

As a next and final step, we will verify that the reputation gain from canceling the project will be smaller in cases of internal succession, i.e. $q > 0$, than it is in cases of external succession. Just as before, we look at the expected prospect from reputation of a high ability manager

$$\begin{aligned} E\left[\pi_{rep}\,|\partial = C \wedge a = a_H\right] &= \omega_R \cdot \tilde{a}(a_H) \\ &= \omega_R \left(a_H \cdot \tilde{a}|_S + (1-a_H)\tilde{a}|_F\right) \\ &= \omega_R \left(a_H \left(\tilde{\eta}|_S a_H + (1-\tilde{\eta}|_S)a_L\right)\right. \\ &\quad \left. +(1-a_H)\left(\tilde{\eta}|_F a_H + (1-\tilde{\eta}|_F a_L)\right)\right). \end{aligned}$$

Using the definitions from above, this yields to

$$\tilde{\eta}|_S = \eta \cdot \underbrace{\frac{d_F(a_H)}{d_F(\hat{a})}}_{<1} \cdot \frac{a_H}{\hat{a}} = \frac{d_F(a_H)}{d_F(\hat{a})} \cdot \tilde{\eta}|_S|_0,$$

$$\tilde{\eta}|_F = \eta \cdot \frac{d_F(a_H)}{d_F(\hat{a})} \cdot \frac{1-a_H}{1-\hat{a}} = \frac{d_F(a_H)}{d_F(\hat{a})} \cdot \tilde{\eta}|_F|_0.$$

Putting these results into the formula for $\tilde{a}$, we can calculate $\tilde{a}$ to be

$$\tilde{a}(a_H) = \frac{d_F(a_H)}{d_F(\hat{a})} \cdot \tilde{a}|_0(a_H) + \left(1 - \frac{d_F(a_H)}{d_F(\hat{a})}\right) \cdot a_L.$$

Just like above, this gives us

$$\tilde{a}(a_H) < \tilde{a}|_0(a_H), \text{ for } \hat{a} > a_L. \tag{26}$$

The results we just gathered from equations (25) and (26) show that $E\left[\Delta\pi_{rep}\right]$ is declining in q. As long as q is small enough such that $E\left[\Delta\pi_{rep}\right] > 0$ the level of $\frac{\omega_R}{\omega_P}$ up to which a manager of high ability does not cancel profitable projects raises. With it the level, up to which the equilibrium exists, rises as well. □

Proof of proposition 3.3.2. Suppose that the equilibrium, in which both types of mangers do not cancel any project, exists. If q is large enough, we have already seen that managers suffer a reputation loss when canceling a project. Now, the equilibrium can only be sustained, if the market believes that a manager, who decides to cancel, is of low ability. In this case and using the notation from above, we get that the reputation payoff from canceling is $\omega_R \cdot a_L$.

The described equilibrium can only exist, if both types of managers have no incentive to cancel unprofitable projects. For a manager of ability a, this means that, for $s = 0$,

$$E\left[\Delta\pi_{inv}(a) + \Delta\pi_{rep}(a)\right] \leq 0. \tag{27}$$

When the market observes that the owner kept the project, it can only update its beliefs about the manager's ability according to the success of the project observed at the end of the game. Since, the internal signal s is not known to the external market, the probability that the manager is of high ability when P is a success is given by

$$\begin{aligned}\breve{\eta}|_S &:= \frac{\Pr\left[a = a_H \wedge P = S\right]}{\Pr\left[P = S\right]} \\ &= \eta \cdot \frac{q \cdot a_H + (1-q)\hat{a}_{pre}}{q \cdot \hat{a} + (1-q)\hat{a}_{pre}},\end{aligned}$$

and, accordingly,

$$\begin{aligned}\breve{\eta}|_F &:= \frac{\Pr\left[a = a_H \wedge P = F\right]}{\Pr\left[P = F\right]} \\ &= \eta \cdot \frac{1-(q \cdot a_H + (1-q)\hat{a}_{pre})}{1-(q \cdot \hat{a} + (1-q)\hat{a}_{pre})}.\end{aligned}$$

As we have already seen, the first term in (27) is negative for large values of q. The second term is positive, as canceling an unprofitable project will increase expected project utility. Thus, when ω_R is chosen large enough, this yields that the negative part of the equation outweighs expected profit from project utility. This means that the equilibrium exists for large enough values of $\frac{\omega_R}{\omega_P}$.

Note that the calculation of the exact boundaries can be analogously done as in proposition 3.2.3 (ii). Due to the parameter q, however, the expression gets more complex. The exact boundaries do not provide further insights for our analysis. Therefore, we can omit these calculations at this point. $\square$

5.5. Proofs of the Results in Chapter 4

PROOF OF PROPOSITION 4.2.1. Before we go into the details of the proof, it is important to understand that when it comes to expected values in this proof, there are always two views. One view is that of the manager, who does not know that he is biased and, therefore, only uses his biased measures. The other view is that of the principal, who is aware of the agent's bias and can use the biased variables (only) in cases where the agent chose them. For example, the principal will use the biased optimal effort in his considerations, but will use his own rational belief about the agent's type when it comes to predicting a period's outcome.

We will proof the statement via induction over the number of periods n.

$\underline{n = 2:}$ We will first have a look at the agent's optimal effort choice in period 1, e_1. As the agent always optimizes the output of the full game, we have to use backward induction. We look at the last period, in this case $t = 2$, first.

In period 2, the agent't goal is to maximize his utility conditional on the output of period 1. Therefore, we have

$$\max_{e_2} E\left[U_2 \left|Y_1\right.\right] = \alpha + \beta e_2 E\left[a \left|Y_1\right.\right] \Pi_H - \frac{1}{2} c e_2^2.$$

The first order condition then yields

$$e_2^* = \frac{\beta E\left[a \left|Y_1\right.\right] \Pi_H}{c}.$$

Using that, we get the ex ante expected utility in that period

$$E\left[U_2\right] = E\left[\alpha + \frac{1}{2c}\beta^2 \Pi_H^2 E\left[a \left|Y_1\right.\right]^2\right]. \tag{28}$$

When we now go back to period 1 and look at the agent's optimal choice, the agent uses the results of the analysis in period 2 to maximize

$$\max_{e_1} E\left[U_1 + U_2\right] = \alpha + \beta e_1 \hat{a}_0 \Pi_H - \frac{1}{2} c e_1^2 + E\left[U_2\right]$$

Remember that we want to show $e_1^{*b} > e_1^*$. Comparing the two first order conditions of the biased and the unbiased case, we get

$$e_1^{*b} > e_1^* \Leftrightarrow \frac{\partial}{\partial e_1} E^b\left[U_2\right] > \frac{\partial}{\partial e_1} E\left[U_2\right]. \tag{29}$$

Using (28), this leads to

$$\begin{aligned} E\left[U_2\right] &= \hat{a}_0 e_1 \left[\alpha + \frac{1}{2c}\beta^2 \Pi_H^2 \left(\hat{\eta}_1\left|_{\Pi_H} a_H + (1-\hat{\eta}_1\left|_{\Pi_H}\right.) a_L\right.\right)^2\right] \\ &\quad + (1-\hat{a}_0 e_1)\left[\alpha + \frac{1}{2c}\beta^2 \Pi_H^2 \left(\hat{\eta}_1\left|_0 a_H + (1-\hat{\eta}_1\left|_0\right.) a_L\right.\right)^2\right]. \end{aligned}$$

We use the formulas for $\hat{\eta}_1$ calculated using Bayes' rule and get

$$\begin{aligned} &= \hat{a}_0 e_1 \underbrace{\left[\alpha + \frac{1}{2c}\beta^2 \Pi_H^2 \left(\frac{\hat{\eta}_0 a_H^2}{\hat{\eta}_0 a_H + (1-\hat{\eta}_0) a_L} + \left(1 - \frac{\hat{\eta}_0 a_H}{\hat{\eta}_0 a_H + (1-\hat{\eta}_0) a_L}\right) a_L\right)^2\right]}_{=:\Theta} \\ &\quad + (1-\hat{a}_0 e_1)\left[\alpha + \tfrac{1}{2c}\beta^2 \Pi_H^2 \left(\tfrac{\hat{\eta}_0(1-a_H e_1) a_H}{\hat{\eta}_0(1-a_H e_1)+(1-\hat{\eta}_0)(1-a_L e_1)}\right.\right. \\ &\qquad \left.\left. + \left(1 - \tfrac{\hat{\eta}_0(1-a_H e_1)}{\hat{\eta}_0(1-a_H e_1)+(1-\hat{\eta}_0)(1-a_L e_1)}\right) a_L\right)^2\right]. \end{aligned}$$

The biased expected values only differ in the Θ term. When the agent has a self attribution bias we get

$$\Theta^b = \left[\alpha + \frac{1}{2c}\beta^2 \Pi_H^2 \left(\frac{b\hat{\eta}_0 a_H^2}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0) a_L} + \left(1 - \frac{b\hat{\eta}_0 a_H}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0) a_L}\right) a_L\right)^2\right]$$

Accordingly, when we compare the partial differentials of the expected utilities in period 2 with respect to the effort, most of the terms cancel out and we get

$$\begin{aligned} \tfrac{\partial}{\partial e_1} E^b\left[U_2\right] - \tfrac{\partial}{\partial e_1} E\left[U_2\right] &= \frac{\partial}{\partial e_1}\left(E^b\left[U_2\right] - E\left[U_2\right]\right) \\ &= \hat{a}_0\left(\Theta^b - \Theta\right) > 0. \end{aligned}$$

The reason this is true is as follows: Note that you can interpret Θ to be Θ^b with $b = 1$, i.e., $\Theta = \Theta^1$. As Θ^b is strictly growing in $\hat{\eta}_1$, and $\hat{\eta}_1$

is strictly growing in b (since $b > 1$), we get $\Theta^b > \Theta^1 = \Theta$. Using (29) and this result, we get $e_1^{*b} > e_1^*$ as stated.

The next step is to look at the optimal effort the agent will choose in period $t = 2$. In period 2, the manager will choose his effort to maximize his utility only in that period. As we have seen in our considerations above, the optimal effort level in that period is given by

$$e_2^* = \frac{\beta E\left[a\,|Y_1\right]\Pi_H}{c}.$$

Since we are looking at this from an ex ante perspective, we get

$$e_2^* = \frac{\beta \hat{a}_1 \Pi_H}{c}.$$

Hence, similar to the line of thought in the first period, we see that

$$e_2^{*b} > e_2^* \Leftrightarrow \hat{a}_1^b > \hat{a}_1 \Leftrightarrow \hat{\eta}_1^b > \hat{\eta}_1 \Leftrightarrow E[\kappa_1] > 0 \tag{30}$$

We will, therefore, look at the expected level of overconfidence at the end of period 1 and show that is positive.

$$\begin{aligned}
\hat{\kappa}_1 &= \hat{\eta}_1^b - \hat{\eta}_1 \\
&= \left[e_1^{*b}\hat{a}_0 \frac{b\hat{\eta}_0 a_H}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0)a_L} + \left(1 - e_1^{*b}\hat{a}_0\right)\frac{\hat{\eta}_0(1 - a_H e_1^{*b})}{(1-\hat{a}_0 e_1^{*b})}\right] \\
&\quad - \left[e_1^*\hat{a}_0\frac{\hat{\eta}_0 a_H}{\hat{a}_0} + (1 - e_1^*\hat{a}_0)\frac{\hat{\eta}_0(1 - a_H e_1^*)}{(1 - \hat{a}_0 e_1^*)}\right] \\
&= \underbrace{e_1^{*b}\hat{a}_0 \frac{b\hat{\eta}_0 a_H}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0)a_L} - e_1^*\hat{a}_0\frac{\hat{\eta}_0 a_H}{\hat{a}_0}}_{=:\Psi} + \hat{\eta}_0(1 - a_H e_1^{*b}) - \hat{\eta}_0(1 - a_H e_1^*) \\
&= \underbrace{\Psi}_{>0} - \underbrace{\hat{\eta}_0 a_H (e_1^{*b} - e_1^*)}_{>0}.
\end{aligned}$$

The interesting thing about this last equation is that we have now isolated the two effects that influence, whether the agent is over- or underconfident. While Ψ compares the two beliefs for a high output, the last term represents the effects of an observed low output. As we have already seen, high outputs create overconfidence. Thus, $\Psi > 0$ is the intuitive consequence.

On the other hand, as we have already seen that $e_1^{*b} > e_1^*$, the effects of an observed low output will be underconfidence.[13] We will show that the overconfidence derived from expected high outputs will overcompensate the underconfidence effect. Therefore, we first have a closer look at

$$\begin{aligned}\Psi &= e_1^{*b}\hat{a}_0 \frac{b\hat{\eta}_0 a_H}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0)a_L} - e_1^* \hat{a}_0 \frac{\hat{\eta}_0 a_H}{\hat{a}_0} \\ &= \hat{\eta}_0 a_H \left[\frac{b e_1^{*b}\hat{a}_0}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0)a_L} - e_1^* \right]\end{aligned}$$

and get

$$\begin{aligned}\hat{\kappa}_1 &= \hat{\eta}_0 a_H \left[\frac{b e_1^{*b}\hat{a}_0}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0)a_L} - e_1^* - e_1^{*b} + e_1^* \right] \\ &= \hat{\eta}_0 a_H \left[\frac{b e_1^{*b}\hat{a}_0}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0)a_L} - \right] - e_1^{*b} \\ &= \hat{\eta}_0 a_H \left[\frac{b e_1^{*b}\hat{a}_0}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0)a_L} - \right] - e_1^{*b} \\ &= \hat{\eta}_0 a_H \left[\frac{b e_1^{*b}\hat{a}_0 - b e_1^{*b}\hat{\eta}_0 a_H - e_1^{*b}(1-\hat{\eta}_0)a_L}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0)a_L} \right] \\ &>^{b>1} \hat{\eta}_0 a_H \left[\frac{b e_1^{*b}\hat{a}_0 - b e_1^{*b}\hat{\eta}_0 a_H - b e_1^{*b}(1-\hat{\eta}_0)a_L}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0)a_L} \right] \\ &= \hat{\eta}_0 a_H \left[\frac{b e_1^{*b}\hat{a}_0 - b e_1^{*b}\hat{a}_0}{b\hat{\eta}_0 a_H + (1-\hat{\eta}_0)a_L} \right] = 0.\end{aligned}$$

Using (30), this concludes the initial step of the induction, since we have shown that the expected optimal effort is strictly larger in both periods.

<u>$(n-1) \to n$:</u> Assume that we have already shown that the expected optimal effort level for the first $n-1$ periods is larger in the biased

[13] The intuition behind this is that, since the agent has exerted more effort in the biased case, a low output is a stronger signal regarding his own ability than it would be with less effort.

than in the unbiased case. The maximization problem of the manager in period n then is

$$\max_{e_n} E\left[Y_{n-1},\ldots,Y_1\right],$$

and the first order condition yields

$$e_n^* = \frac{\beta \hat{a}_{n-1}\Pi_H}{c}.$$

Taking the same arguments as in the two period case above, we have that the expected effort level in period n is larger for the biased case if

$$\begin{aligned}
\hat{\kappa}_{n-1} &= \hat{\eta}^b_{n-1} - \hat{\eta}_{n-1} \\
&= \left[e^{*b}_{n-1}\hat{a}_0 \frac{b\hat{\eta}^b_{n-2}a_H}{b\hat{\eta}^b_{n-2}a_H + (1-\hat{\eta}^b_{n-2})a_L} + \left(1 - e^{*b}_{n-1}\hat{a}_0\right)\frac{\hat{\eta}_{n-2}(1-a_H e^{*b}_{n-1})}{(1-\hat{a}_0 e^{*b}_{n-1})}\right] \\
&\quad - \left[e^{*}_{n-1}\hat{a}_0 \frac{\hat{\eta}_{n-2}a_H}{\hat{a}_0} + (1 - e_{n-1}1^{*}\hat{a}_0)\frac{\hat{\eta}_{n-2}(1-a_H e^{*}_{n-1})}{(1-\hat{a}_0 e^{*}_{n-1})}\right] > 0
\end{aligned}$$

When you compare this condition to the one in the upper case of only two periods, the only difference is that this time the prior belief $\hat{\eta}^b_{n-2}$ in the biased case is different to $\hat{\eta}_{n-2}$ in the unbiased case. In the two period situation we had before these priors were the same.[14] By assumption, however, we know that $\hat{\eta}^b_{n-2} > \hat{\eta}_{n-2}$. Therefore, to show $\hat{\kappa}_{n-1} > 0$ it is enough to show this for some $\tilde{\kappa}_{n-1}$ (instead of κ_{n-1}), where we substitute $\hat{\eta}^b_{n-2}$ by $\hat{\eta}_{n-2}$ in the previous formula of $\hat{\kappa}_{n-1}$.[15] But with this substitution, the whole case reduces to the one we have already looked at in period 2. Hence, this concludes the proof. □

Proof of proposition 4.2.3. Suppose that in period i the manager observes a low output of his work $Y_i = 0$. Then, by definition, we get

$$\kappa_i = \hat{\eta}^b_i - \hat{\eta}_i = \hat{\eta}^b_{i-1}\frac{1-a_H e^{*b}_i}{1-\hat{a}_{i-1}e^{*b}_i} - \hat{\eta}_{i-1}\frac{1-a_H e^{*}_i}{1-\hat{a}_{i-1}e^{*}_i}.$$

[14] Both were $\hat{\eta}_0$.

[15] Note that this is true as the posterior belief is monotonically increasing in the prior belief. Therefore, when we use the smaller prior belief, we get a smaller expected level of confidence. And if this is larger then 0 then the original level of confidence is also larger.

Now, from proposition 4.2.1, we know that $e_i^{*b} > e_i^*$. So let δ_i be the positive difference between the biased and unbiased effort, i.e., $e_i^{*b} = e_i^* + \delta$. Putting this into the above formula, we get

$$\begin{aligned}
\kappa_i &= \hat{\eta}_{i-1}^b \left[\frac{1 - a_H e_i^*}{1 - \hat{a}_{i-1} e_i^*} - \frac{\delta (a_H - \hat{a}_{i-1})}{(1 - \hat{a}_{i-1} e_i^{*b})(1 - \hat{a}_{i-1} e_i^*)} \right] - \hat{\eta}_{i-1} \frac{1 - a_H e_i^*}{1 - \hat{a}_{i-1} e_i^*} \\
&= \underbrace{(\hat{\eta}_{i-1}^b - \hat{\eta}_{i-1})}_{=\kappa_{i-1}} \underbrace{\frac{1 - a_H e_i^*}{1 - \hat{a}_{i-1} e_i^*}}_{<1} - \underbrace{\frac{\delta \hat{\eta}_{i-1}^b (a_H - \hat{a}_{i-1})}{(1 - \hat{a}_{i-1} e_i^{*b})(1 - \hat{a}_{i-1} e_i^*)}}_{>0} \\
&< \kappa_{i-1}.
\end{aligned}$$

In particular, since the manager is initially neither under- nor overconfident, i.e., $\kappa_0 = 0$, if a low output is observed right in the first period, this gives us

$$\kappa_1 < \kappa_0 = 0.$$

□

Proof of proposition 4.2.4. We will first show that this is true in the unbiased case, i.e., that a rational manager is expected to learn his true ability during the course of the game. It is sufficient to show that $\hat{\eta}_i$ (or $\hat{\eta}_i^b$ respectively) will converge to 1 (0) for a high (low) ability manager. Hence, we will analyze the two possible types of ability separately

(i) $\underline{a = a_H}$: Let Δ_i be the difference between a_H and $\hat{a}_i$, i.e., $\Delta_i = a_H - \hat{a}_i$. We want to examine the behavior of $\hat{\eta}_i$ as i approaches infinity. Since the manager's ability is high, we get

$$\begin{aligned}
\hat{\eta}_{i+1} &= e_i^* a_H \hat{\eta}_i \frac{a_H}{\hat{a}_i} + (1 - e_i^* a_H) \hat{\eta}_i \frac{1 - a_H e_i^*}{1 - e_i^* \hat{a}_0} \\
&= e_i^* (\hat{a}_i + \Delta_i) \hat{\eta}_i \frac{a_H}{\hat{a}_i} + (1 - e_i^* \hat{a}_i - e_i^* \Delta_i) \hat{\eta}_i \frac{1 - a_H e_i^*}{1 - e_i^* \hat{a}_0} \\
&= \hat{\eta}_i (a_H + 1 - a_H) + e_i^* \Delta_i \hat{\eta}_i \left(\frac{a_H}{\hat{a}_i} - \frac{1 - a_H e_i^*}{1 - e_i^* \hat{a}_i} \right) \\
&= \hat{\eta}_i + \underbrace{e_i^* \Delta_i \hat{\eta}_i \left(\frac{\Delta_i}{\hat{a}_i (1 - e_i^* \hat{a}_i} \right)}_{>0}
\end{aligned}$$

Thus, we have shown that, in case $a = a_H$, the expected belief about the probability that the manager is of high ability is strictly monotonically increasing. We will now show that

$$\begin{aligned} \hat{\eta}_{i+1} &= \hat{\eta}_i + e_i^* \Delta_i \hat{\eta}_i \left(\frac{\Delta_i}{\hat{a}_i (1 - e_i^* \hat{a}_i)} \right) \leq 1 \\ &\Leftrightarrow e_i^* \Delta_i^2 \hat{\eta}_i \leq (1 - \hat{\eta}_i)(1 - e_i^* \hat{a}_i) \hat{a}_i. \end{aligned}$$

Since $e_i^* < 1$, it is sufficient to show that

$$\Delta_i^2 \hat{\eta}_i \leq (1 - \hat{\eta}_i)(1 - \hat{a}_i)\hat{a}_i.$$

To show this, we have to distinguish two cases

$\hat{\eta}_\mathbf{i} \leq \mathbf{\frac{1}{2}}$: By definition, we know that $\Delta_i < \hat{a}_i$ and $1 - \hat{a}_i > a_H - \hat{a}_i = \Delta_i$. Furthermore, since $\hat{\eta}_i \leq \frac{1}{2}$, we have $\hat{\eta}_i \leq (1 - \hat{\eta}_i)$. Therefore, all of the terms on the left side of the equation are smaller than one corresponding term on the right hand side. That concludes this case.

$\hat{\eta}_\mathbf{i} > \mathbf{\frac{1}{2}}$: In this case, on the contrary, we have that $1 - \hat{\eta}_i < \frac{1}{2}$. We get

$$\Delta_i = a_H - \hat{a}_i = a_H - \hat{\eta}_i a_H - (1 - \hat{\eta}_i) a_L = (1 - \hat{\eta}_i)(a_H - a_L).$$

This means that we have to show

$$\begin{aligned} (1 - \hat{\eta}_i)^2 (a_H - a_L)^2 \hat{\eta}_i &< (1 - \hat{\eta}_i) \hat{a}_i (1 - \hat{a}_i) \\ \Leftrightarrow (1 - \hat{\eta}_i)(a_H - a_L)^2 \hat{\eta}_i &< \hat{a}_i (1 - \hat{a}_i). \end{aligned}$$

On the other hand, we know that $a_H - a_L < \frac{1}{2} < \hat{a}_i$ and

$$(1 - \hat{\eta}_i)(a_H - a_L) = \Delta_i < (1 - \hat{a}_i),$$

which concludes this case.

We have shown that $\hat{\eta}_i$ is a strictly monotonically increasing series, which is limited by 1 (i.e., $\Delta_i = 0$). Thus, $\hat{\eta}_i$ is a Cauchy sequence that converges to 1.

(ii) $\underline{a = a_L}$: Consider $\tilde{\Delta}_i := \hat{a}_i - a_L > 0$. Then a similar calculation to the case above shows that

$$\hat{\eta}_{i+1} = \hat{\eta} - e_i^* \tilde{\Delta}_i \hat{\eta}_i \frac{\Delta_i}{\hat{a}_i(1 - e_i^* \hat{a}_i)}.$$

Following the same line of thought as above, we have to show

$$\begin{aligned} \hat{\eta}_i - e_i^* \tilde{\Delta}_i \hat{\eta}_i \frac{\Delta_i}{\hat{a}_i(1 - e_i^* \hat{a}_i)} &\geq 0 \\ \Leftrightarrow 1 - e_i^* \tilde{\Delta}_i \frac{\Delta_i}{\hat{a}_i(1 - e_i^* \hat{a}_i)} &\geq 0 \\ \Leftrightarrow e_i^* \tilde{\Delta}_i \Delta_i &\leq \hat{a}_i(1 - e_i^* \hat{a}_i). \end{aligned}$$

And, since we know that $\tilde{\Delta}_i \leq \hat{a}_i$, it is enough to show

$$\begin{aligned} e_i^* \Delta_i &\leq 1 - e_i^* \hat{a}_i \\ \Leftrightarrow e_i^* (\Delta_i + \hat{a}_i) &\leq 1 \\ \Leftrightarrow e_i^* a_H &< 1, \end{aligned}$$

which is fulfilled. This concludes the proof for the unbiased case.

In a next step we will look at the biased case. Just like in the unbiased case, we have to distinguish the two possible cases the ability can take.

(i) $\underline{a = a_H}$: Let Δ_i^b be defined just like Δ_i for the biased case, and let $\tilde{b} = b - 1 > 0$. Then we have

$$\begin{aligned} \hat{\eta}_{i+1}^b &= e_i^{*b} a_H \hat{\eta}_i^b \frac{b a_H}{\hat{\eta}_i^b a_H b + (1 - \hat{\eta}_i^b) a_L} \\ &\quad + (1 - e_i^{*b} a_H) \hat{\eta}_i^b \frac{1 - a_H e_i^{*b}}{\hat{\eta}_i^b (1 - e_i^{*b} a_H) + (1 - \hat{\eta}_i^b)(1 - e_i^{*b} a_L)} \\ &= \hat{\eta}_i^b + e_i^{*b} \hat{\eta}_i^b \left(\frac{\Delta_i^{b2}}{\hat{a}_i^b (1 - e_i^{*b} \hat{a}_i^b)} + \frac{a_H^2 a_L \tilde{b} (1 - \hat{\eta}_i^b)}{\hat{a}_i^{b2} + \tilde{b} \hat{\eta}_i^b a_H \hat{a}_i^b} \right) \end{aligned}$$

To conclude this part of the proof, we want to show that, if the bias b is not too large,

$$\hat{\eta}_{i+1} \leq 1 \tag{31}$$

holds for all i. Using the associated formula for (31) and solving it for $\tilde{b}$, we get an expression of the form

(32)
$$\tilde{b}_i = \frac{\hat{a}_i^{b2} - e_i^{*b}\hat{a}_i^{b3} - e_i^{*b}}{e_i^{*b}\hat{\eta}_i^{b2}(a_H - a_L)\Delta_i^b a_H + e_i^{*b}\hat{\eta}_i^b a_H^2 a_L(1 - e_i^{*b}\hat{a}_i^b) - \hat{\eta}_i^b a_H \hat{a}_i^b + e_i^{*b}\hat{\eta}_i^b a_H \hat{a}_i^{b2}}$$

for each i. As all of these solutions $\tilde{b}_i$ are strictly larger than

$$\frac{\min\{a_H^2 - a_H^3, a_L^2 - a_L^3\}}{(a_H - a_L)(a_H - a_0)a_H + a_H^2 a_L - \hat{\eta}_0 a_H a_L + a_H^3} > 0,$$

we get that $\breve{b} := 1 + \inf_i \tilde{b}_i$ is well defined and for all $b \leq \breve{b}$ it converges to 1. That concludes this part of the proof.

(ii) $\underline{a = a_L}$: On the other hand, let $\tilde{\Delta}_i^b$ also be defined analogous to the unbiased case. In the same way as above, we get[16]

$$\hat{\eta}_{i+1}^b = \hat{\eta}_i^b + e_i^{*b}\hat{\eta}_i^b \left[-\frac{\tilde{\Delta}_i \Delta_i}{\hat{a}_i^b(1 - e_i^{*b}\hat{a}_i^b)} + \frac{a_H a_L^2 \tilde{b}(1 - \hat{\eta}_i^b)}{\hat{a}_i^{b2} + \tilde{b}\hat{\eta}_i^b a_H \hat{a}_i^b} \right] \geq 0.$$

The first term that is subtracted is the same as in the unbiased case. New is the extra positive term which results from the biased update for high outputs.

These two effects are working in opposite directions, and we have to look at them more closely to understand, how they will affect the manager's learning.

First of all, note that the negative term has its maximum when the uncertainty about the manager's ability is the largest, i.e. $\hat{\eta}_i = \frac{1}{2}$. This is the case for $\hat{a}_i = \frac{a_L + a_H}{2}$. As $\hat{a}_i^b$ gets closer to either a_L or a_H, this negative term approaches 0.

Secondly, the positive term is monotonically decreasing in $\hat{a}_i^b$ from $a_H\tilde{b}$ in a_L to 0 in a_H and is increasing in $\tilde{b}$.

[16] It is important to keep in mind that $\hat{\eta}_i^b$, Δ_i^b and $\tilde{\Delta}_i^b$ are all functions of the expected abilities $\hat{a}_i^b$.

Next, let $\bar{b}$ be defined in such a way that the smallest possible first negative term,[17] and the positive second term coincide in $\frac{a_L+a_H}{2}$ i.e.,

$$\inf_i \left\{ \frac{\frac{1}{4}(a_H - a_L)^2}{\frac{a_L+a_H}{2}\left(1 - e_i^* b \frac{a_L+a_H}{2}\right)} \right\} = \frac{\frac{1}{2} a_H a_L^2 (\bar{b} - 1)}{\frac{a_L+a_H}{2} + \frac{1}{2}(\bar{b}-1) a_H \frac{a_L+a_H}{2}}$$

$$\Leftrightarrow \bar{b} = 1 + \frac{(a_H - a_L)^2 + \inf_i \left\{ e_i^{*b} \right\} a_H a_L^2 (a_L + a_H)}{a_H (2a_L^2 - \frac{1}{2}(a_H - a_L)^2}.$$

Then for $b < \bar{b}$, by construction[18] for any initial value $\hat{\eta}_0$ the series of $\hat{\eta}_i^b$ will fall below $\frac{1}{2}$ until the two terms (negative and positive) cancel out and the series becomes constant. So $\bar{a}_L$ is the solution to the equation when both effects are equal, i.e., the solution to

$$\frac{\tilde{\Delta}_i \Delta_i}{\hat{a}_i (1 - e_i^{*b} \hat{a}_i)} = \frac{a_H a_L^2 \tilde{b} (1 - \hat{\eta}_i^b)}{\hat{a}_i^{b2} + \tilde{b} \hat{\eta}_i^b a_H \hat{a}_i^b}.$$

Accordingly, we have shown that for small enough values of b, a biased manager's beliefs, if he is of low ability, will fall to a level $\bar{a}_L$. This ability level lies above a_L. All of this is the result of the growing influence of the bias when the belief about the manager's ability sinks upon a high output.

(iii) Putting the two results together, let b^* be the minimum of the two limits, i.e., $b^* = \min(\breve{b}, \bar{b})$. Then for $b < b^*$ we get the results of both (i) and (ii) and hence the proof.

□

PROOF OF PROPOSITION 4.2.6. This proof is very similar to the last proof where we looked at a low ability manager. We will, therefore, refer to that proof on some occasions as they are mostly identical.

We look at $\hat{\kappa}_{i+1}$, which is defined as

$$\hat{\kappa}_{i+1} = \hat{\eta}_{i+1}^b - \hat{\eta}_{i+1}.$$

[17] This again exists as the term has its minimum for $e_i^{*b} = 0$

[18] And the fact that the positive term is decreasing quicker as the negative term as $\hat{a}_i^b$ approaches a_H.

The first thing to note is that, for all i, we have $\hat{\eta}_i = \hat{\eta}_0$. That is because from a rational point of view $\hat{\eta}_0$ is the expected value of the probability that the manager is of high ability. When no new information becomes available, this does not change when it is recalculated. The biased $\hat{\eta}_i^b$, however, will change from a rational point of view. The principal is aware that there is a difference between the agents assessment of reality and the rational one. Accordingly, we get

$$\hat{\kappa}_{i+1} = e_i^{*b}\hat{a}_0 \frac{b\hat{\eta}_i^b a_H}{b\hat{\eta}_i^b a_H + (1-\hat{\eta}_i^b)a_L} + (1-e_i^{*b}\hat{a}_0)\frac{\hat{\eta}_i^b(1-a_H e_i^{*b})}{1-\hat{a}_i e_i^{*b}} - \hat{\eta}_0.$$

Let $\nabla_i = \hat{a}_i^b - \hat{a}_0 \geq 0$ be the positive difference between the biased and the unbiased ability assessment.[19] Then, just like in the proof above, we can rewrite $\hat{\kappa}_{i+1}$ with the notation from above as

$$\begin{aligned}
\hat{\kappa}_{i+1} &= \hat{\eta}_i^b + e_i^{*b}\hat{\eta}_i^b \left[-\frac{\nabla_i \Delta_i}{\hat{a}_i^b(1-e_i^{*b}\hat{a}_i^b)} + \frac{a_H \hat{a}_0 a_L \tilde{b}(1-\hat{\eta}_i^b)}{\hat{a}_i^{b2} + \tilde{b}\hat{\eta}_i^b a_H \hat{a}_i^b} \right] - \hat{\eta}_0 \\
&= \hat{\kappa}_i + e_i^{*b}\hat{\eta}_i^b \left[-\frac{\nabla_i \Delta_i}{\hat{a}_i^b(1-e_i^{*b}\hat{a}_i^b)} + \frac{a_H \hat{a}_0 a_L \tilde{b}(1-\hat{\eta}_i^b)}{\hat{a}_i^{b2} + \tilde{b}\hat{\eta}_i^b a_H \hat{a}_i^b} \right].
\end{aligned}$$

Finally, if b is small enough, the first negative term will outweigh the large positive one in the beginning. The series of $\hat{\kappa}_i$ will, thus, decrease. When that happens, $\hat{\eta}_i^b$ will get closer and closer to $\hat{\eta}_0$. The biased $\hat{a}_i^b$ will approach $\hat{a}_0$. The result is that ∇_i becomes smaller and smaller until the two terms above are equal. This means $\hat{\kappa}_i$ will become stationary at some level $\underline{\kappa}$. □

[19] Note that ∇_i and κ_i are closely related as they both basically measure the same degree of confidence.

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