# Estimation Risk and Earnings-based CEO Cash Pay

by

Claudine Mangen

Submitted in Partial Fulfillment
of the
Requirements for the Degree
Doctor of Philosophy

Supervised by
Professor Jerold L. Zimmerman

William E. Simon Graduate School of Business Administration

University of Rochester
Rochester, New York
2007

*To my parents, Marcelle and Alphonse.*

*Carpe diem quam minimum credula postero (Horace).*

# Curriculum Vitae

Claudine Mangen was born in Luxembourg Ville, Luxembourg on June 15th, 1974. She moved to Switzerland in 1993 to attend the Université de Lausanne, in Lausanne, and graduated in 1996 with a Bachelor's degree in Economics (License en Sciences Economiques). Claudine started her graduate education at the Université de Lausanne in the fall of 1996, and received her Master's degree in Finance (Diplôme Postgrade en Banques et Finance) in January 1998.

Claudine entered the Ph.D. program at the William E. Simon Graduate School of Business Administration in the autumn of 1998. She was awarded a Simon School Fellowship from 1998 to 2000, an Olin Fellowship in 2002, and a Fellowship from the Luxembourgian Scientific and Applied Research Fund from 2003 to 2005. In 2001, Claudine received her Master of Science in Applied Economics. Claudine pursued her research on executive compensation under the direction of Professor Jerold L. Zimmerman.

**Acknowledgments**

I would like to thank the many people who have helped me in my doctoral work. My thoughts turn first to my advisor, Jerold L. Zimmerman, without whom this dissertation would not have been possible. I am profoundly grateful for the time and effort that he spent guiding me, for the many valuable comments and discussions that I continue to benefit from, and for his enduring support. I also would like to express my deepest gratitude to James A. Brickley whose insights have greatly improved my work, and to Andrew Leone for his many worthy suggestions.

During my time at the University of Rochester, I have been fortunate to interact with the faculty of accounting and finance at the William E. Simon Graduate School of Business Administration, as well as with the faculty at the Department of Economics. Their teachings continue to shape my thoughts, and have had an important impact on my work. For this, I thank all of them. I am grateful to Liz Demers and Philip Joos for their encouragement and comments during this project. Finally, I want to thank the many people, too numerous to list explicitly, whom I met at research seminars, workshops, conferences, and in university hallways, and whose suggestions have improved my work.

I am lucky to have had an unwavering network of close friends, who were very present in my life and work in Rochester. I particularly wish to thank Ana Albuquerque, Samuel Danthine, Andreas Gintschel, Nicole Hausmann, Luis Marques, Alessia Testa, and Michela Verardo. Last but not least, my thoughts turn to my family, who have been a harbor during quiet and stormy seas. Marcelle, Alphonse, Jean-Jacques, Jean-Pierre and Caroline, I am grateful for your love, support, and wisdom.

## Abstract

This thesis re-examines the role of risk in earnings-based CEO cash pay. The executive compensation literature shows that the sensitivity of CEO cash pay to earnings falls with risk resulting from noise in earnings. This literature assumes that the parameters of the distribution of noise in earnings are known when earnings-based CEO cash pay is set. In reality, this assumption is unlikely to hold. This thesis therefore investigates the more general case where the parameters of the distribution of noise in earnings are not known, and there is estimation risk.

Chapter 1 presents a principal-agent model of how estimation risk affects earnings-based CEO cash pay. In the model, the CEO and the compensation committee learn rationally over time about the parameters of the distribution of noise in earnings, using past earnings noise observations. When the record of past earnings noise observations is shorter, there is less learning, and estimation risk is higher. The model shows that higher estimation risk leads to a lower weight on earnings.

Chapter 2 presents an empirical analysis of how estimation risk impacts earnings-based CEO cash pay. Using two different proxies for estimation risk, this thesis finds support for its prediction from its model in Chapter 1. The evidence indicates that when estimation risk is high, the weight on earnings is up to 87% lower than when estimation risk is low, after controlling for other sources of risk already examined in the literature. This finding is subject to the caveat that the two estimation risk proxies may capture sources of risk other than estimation risk, if these other sources of risk are not adequately controlled for. Furthermore, Chapter 2 analyzes how estimation risk affects performance measures other than earnings, such as subjective and non-financial performance measures. The evidence indicates that firms shift the

weight onto subjective performance measures when estimation risk is high. Firms appear to mitigate the impact of estimation risk by moving towards subjective performance measures, which allow them to evaluate CEO performance ex post after having observed earnings.

Chapter 3 examines some particularities of earnings-based CEO cash pay, such as performance standards and bonus bounds. It shows that even when performance standards and bonus bounds are accounted for, estimation risk continues to affect the sensitivity of CEO cash pay to earnings. Other sensitivity tests are performed and show that the results hold.

# Contents

# List of Tables

# Introduction

CEO cash pay contracts frequently use earnings as a performance measure. Earnings introduce risk into CEO cash pay that stems from variations in earnings noise. Earnings noise captures items in earnings that are unrelated to CEO effort, such as actions of competitors or customers (Lambert, 1993). Contracting theory predicts that the sensitivity of CEO cash pay to earnings falls as risk from earnings noise rises (Lambert, 2001). The empirical literature, which usually supports this prediction, uses various risk constructs. In general, these empirical risk measures rely on the historical time-series variance of earnings (Lambert and Larcker, 1987; Core et al., 2003), or its systematic component (Lambert and Larcker, 1987; Sloan, 1993). Two problems are associated with these empirical risk constructs. First, the historical time-series variance of earnings or its systematic component may not capture risk if this risk changes over time, such as when a firm restructures its operations. Second, empirical risk constructs based on the historical time-series variance of earnings or its systematic component may not reflect all relevant sources of risk. Consistent with these concerns, Bushman and Smith (2001) suggest that fundamental questions still remain about the proper empirical risk measures for contracting purposes. If the empirical risk constructs do not capture true risk, then the empirical weight on earnings obtained in a multiple regression framework is biased.[1]

[1]The direction of this bias cannot be determined in a multiple regression framework, such as those generally used in the empirical compensation literature (Greene, 1997).

The present thesis contends that conventional empirical risk constructs omit an important source of risk, namely estimation risk. Estimation risk refers to uncertainty about the parameters of the earnings noise distribution.[2] The earnings noise distribution is the probability density function of the noise in earnings. The executive compensation literature has traditionally assumed that the parameters of the earnings noise distribution are known when CEO cash pay is set for the year ahead. In reality however, this assumption unlikely holds. The CEO and the compensation committee, who determine next year's CEO cash pay together, likely do not know the parameters of the earnings noise distribution. The purpose of this thesis is therefore to analyze how uncertainty about the parameters of the earnings noise distribution affects earnings-based CEO cash pay.

This thesis presents a traditional principal-agent model to which it adds parameter uncertainty about the earnings noise distribution. It is assumed that the CEO and the compensation committee learn about the unknown parameters of the earnings noise distribution in a Bayesian manner. Specifically, the CEO and the compensation committee update their prior beliefs about the parameters of the earnings noise distribution using past noise realizations. Within the traditional principal-agent model, past noise realizations can be backed out of past earnings, since the CEO's optimal past effort is known.[3] Through their updating process, the CEO and the compensation committee learn about the parameters of the earnings

[2]Estimation risk is also called parameter uncertainty. The definition for estimation risk used in the current thesis parallels the definition of estimation risk from the asset pricing literature (see for instance Lewellen and Shanken (2002)).

[3]The compensation committee knows the CEO's optimal past effort, because when it sets CEO cash pay, it is as if it selects both the parameters of CEO cash pay and the optimal CEO effort, as further discussed later on. However, since CEO effort is not observable, the compensation committee cannot verify its conjecture about CEO effort.

noise distribution. When the record of past noise observations is shorter, there is less learning, and estimation risk is higher. The model in this thesis then predicts that higher estimation risk leads to a lower sensitivity of CEO cash pay to earnings. Two estimation risk proxies are used to test this prediction.

The first estimation risk proxy is the dispersion of analysts' forecasts for next year's earnings. The use of analysts' forecast dispersion to capture estimation risk has been advocated since Barry and Brown (1985). When the CEO and the compensation committee have a shorter record of past noise observations to learn about the parameters of the earnings noise distribution and estimation risk is higher, analysts too likely have less information about the firm. Analysts' opinions then converge to a lesser extent, and the dispersion of their forecasts rises. The thesis therefore predicts that the weight on earnings declines as the dispersion of analysts' forecasts for next year's earnings increases. Using data on CEO cash pay from EXECUCOMP between 1992 and 2004, this thesis finds support for this hypothesis and shows that estimation risk affects the weight on earnings in a statistically and economically significant manner. When the dispersion of analysts' forecasts for year ahead earnings has the highest value, the weight on earnings is about 58% lower than when the dispersion of analysts' forecasts has the lowest value. The results are robust to the inclusion of other firm and CEO characteristics that influence the weight on earnings, such as growth options (Smith and Watts, 1992; Baber et al., 1996), earnings persistence (Baber et al., 1998), CEO stock ownership (Sloan, 1993), and CEO tenure (Baber et al., 1998). More importantly, the findings continue to hold after controlling for traditional sources of risk other than estimation risk (Lambert and Larcker, 1987; Sloan, 1993).

The second estimation risk proxy relies on economic shocks. Because earnings are not timely, next year's earnings noise distribution is affected by current shocks, such as the entry of a new competitor. Compensation committees likely can observe such shocks when they set CEO cash pay for the year ahead. Shocks to the earnings noise distribution modify the parameters of this distribution. To learn about the new parameters of the earnings noise distribution, the CEO and the compensation committee look at how similar past shocks have affected past earnings noise. When shocks are more extreme, the CEO and the compensation committee likely have a shorter record of how similar past shocks have affected past earnings noise. This happens because shocks occur less often as they become larger (Balke and Fomby, 1991, 1994). Therefore, when shocks are more extreme, learning about the parameters of the earnings noise distribution is more difficult, and estimation risk rises. The size of shocks is captured using the absolute value of stock returns, because returns are timely in reflecting information and because the absolute value abstracts away from the sign of the shocks. This thesis therefore predicts that the sensitivity of CEO cash pay to earnings is lower when the absolute value of past returns is higher. The results support this prediction and show that firms with the highest absolute value of past returns have a weight on earnings that is about 87% smaller than firms with the lowest absolute value of past returns. The findings hold after controlling for other firm and CEO characteristics known to affect the weight on earnings as well as for sources of risk other than estimation risk.

The positive correlation between earnings and past returns suggests that most shocks affect earnings noise during several years (Collins et al., 1994). As time goes by, the CEO and the compensation committee then have a longer record of the effect of a particular shock on the earnings noise distribution. Consequently, they learn over time how a specific shock impacts the parameters of the earnings noise distribution, and estimation risk declines. This thesis therefore predicts that the sensitivity of CEO cash pay to earnings is lower for more extreme returns from the more recent past than for more extreme returns from further in the past. The analysis provides some support for this prediction, based on up to three years of past returns. Returns from each of the two years prior to the sample year have a negative impact on the pay-performance sensitivity to earnings, whereas returns from the third year prior to the sample year usually do not affect the weight on earnings. The strongest negative impact on the pay-performance sensitivity to earnings generally involves returns from the year prior to the sample year. Overall, this evidence suggests that estimation risk is mitigated over time as the CEO and the compensation committee learn about the effect of a specific shock on the earnings noise distribution.

The theoretical literature suggests that an increase in risk resulting from earnings noise leads to a higher relative weight on non-earnings based performance measures, under certain conditions (Holmström and Milgrom, 1991; Datar et al., 2001). CEO cash pay contracts frequently include non-earnings based performance measures such as customer satisfaction (Ittner et al., 1997), and subjective performance measures (Bushman et al., 1996; Murphy and Oyer, 2003). This thesis therefore predicts that the relative weight on non-financial and subjective performance measures increases with estimation risk. The evidence supports this hypothesis, based on a sample of 196 firms subject to large economic shocks and thus to high estimation risk, and 196 control firms that do not experience economic shocks. Firms rely more intensively on subjective performance measures following large shocks. For instance, about 76.0% of the firms use subjective performance measures in the year following a large shock, up from 70.9% in the year of the shock. The percentage of control firms relying on subjective performance measures declines, from about 71.4% in the year of a large shock to 63.8% in the year following the shock. The difference between firms and control firms is significant in the year after the shock, but not in the year of the shock. These results suggest that when high estimation risk makes it difficult for compensation committees to set the weight on earnings objectively ex ante, they evaluate CEO contribution to firm performance subjectively ex post, after having observed earnings.

This thesis adds to the current literature in three ways. Its most significant contribution is that it broadens our understanding of risk in CEO cash pay, by analyzing a so far unexplored yet important source of risk, namely estimation risk. This thesis shows both theoretically and empirically that estimation risk can substantially affect earnings-based CEO cash pay. Estimation risk is a source of risk incremental to other sources of risk already examined in the executive compensation literature. These other sources of risk obtain even when there is no estimation risk, since they capture known variations caused by earnings noise around a known mean of the earnings noise distribution. Estimation risk, on the other hand, arises because the mean and/or the variance of the earnings noise distribution are not known. The results in this thesis are robust to including controls for the traditional sources of risk, which suggests that its empirical estimation risk proxies in fact capture an additional source of risk. This conclusion relies on the assumption that sources of risk other than estimation risk are adequately controlled for. If this is not the case, then the two estimation risk proxies may capture traditional sources of risk in addition to estimation risk, and thus be better measures of these risk sources than the empirical constructs previously used in the literature. Overall, this thesis thus responds to the call from Bushman and Smith (2001) to further examine the empirical constructs for risk in performance measures. Its evidence has implications for researchers who examine CEO pay. In settings where estimation risk is high, it is important to control for it, because it can substantially affect the sensitivity of CEO cash pay to earnings. Researchers can capture estimation risk using the dispersion of analysts' forecasts, or the absolute size of past stock returns.

Second, the thesis contributes to the literature on estimation risk. The consequences of estimation risk have long been explored in asset pricing (starting with Kalymon (1971), see Lewellen and Shanken (2002) for later work). More recently, the literature has begun to analyze how rational agents learn about unknown parameters in other settings. For instance, Lang (1991) examines how investors learn about the parameters of the earnings distribution, while Markov and Tamayo (2006) investigate this question from the perspective of analysts. The compensation literature has so far been silent on the issue of parameter uncertainty other than uncertainty about CEO ability. For example, studies have examined how learning about CEO ability affects the weight on returns in CEO cash pay (Murphy, 1986), and the effectiveness of reputation as an incentive mechanism (Holmström, 1999). However, the compensation literature has traditionally assumed that the parameters of the earnings noise distribution are known. In reality, this assumption is unlikely to hold, so that estimation risk arises. Similar to other work on parameter uncertainty, such as Lewellen and Shanken (2002) and Markov and Tamayo (2006), this thesis uses the Bayesian framework to analyze the effects of estimation risk. The present thesis therefore extends the literature on estimation risk and on Bayesian learning by examining parameter uncertainty in the specific context of earnings-based CEO cash pay.

Third, this thesis contributes to the literature on subjective performance measures. Its evidence suggests that when estimation risk is high, compensation committees use earnings less as a purely objective performance measure and more as a subjective performance measure that can be adjusted at their discretion ex post, once earnings have been observed. This result is consistent with the argument that subjective performance measures mitigate problems with objective performance measures, such as their risk (Baker et al., 1994; Hayes and Schaefer, 2000; Murphy and Oyer, 2003; Gibbs et al., 2004). The current thesis is the first to document directly that the use of subjective performance measures is associated with risk. Bushman et al. (1996) and Murphy and Oyer (2003) analyze the use of discretion in performance measures, and show that subjective performance measures are associated with growth options and product time horizons. However, their evidence does not support their prediction that the use of subjective performance evaluation increases with risk in financial performance measures. While Ittner et al. (1997) find some evidence that risk has an effect, they focus on non-financial performance measures, and not on subjective performance measures.

The rest of this thesis is organized as follows. Chapter 1 presents a principal-agent model of how estimation risk affects earnings-based CEO cash pay and develops testable predictions. Chapter 2 outlines the empirical analysis, and discusses the main results. Chapter 3 further examines the specific characteristics of CEO cash pay, such as performance standards and bonus bounds, and performs sensitivity tests. The last part of this thesis concludes.

# Chapter 1

# A model for the effect of estimation risk on CEO cash pay

This chapter builds a simple principal-agent model of how estimation risk affects earnings-based CEO cash pay. It starts off by briefly describing the intuition of the model, before detailing the derivation of the model's main result, and developing testable predictions.

## 1.1 Intuition of the model

CEO cash pay for the year ahead $t$ is set by the compensation committee in $t-1$. While there is little direct evidence in the academic literature on the chronology of pay setting, anecdotal evidence from proxy statements indicates that CEO cash pay is determined ex ante on a yearly basis. For instance, Cygnus Inc. writes in its 1995 proxy statement concerning the structure of CEO bonus pay that "The Company guidelines are established at the beginning of the year by executive management and approved by the Committee and the Board of Directors" (Cygnus Inc., 1995). The analysis in this thesis focusses on earnings, because earnings are the most common performance measure in CEO cash pay contracts (Murphy, 2000). Earnings $A$ in year $t$ contain information about CEO effort and can be written as follows:

$$A = e + x, \tag{1.1}$$

where $e$ is unobservable effort that the CEO provides next year and $x$ is a random variable, distributed as $N(\theta, \sigma^2)$. The variable $x$ captures noise in year ahead earnings that is unrelated to next year's CEO effort, such as the introduction of a new product by a competitor. Since CEO effort $e$ and earnings noise $x$ cannot be observed separately, CEO cash pay is based on their sum, earnings $A$. Following equation (1.1), earnings $A$ is then distributed as $N(e + \theta, \sigma^2)$.

In the traditional principal-agent analysis (see for instance Milgrom and Roberts (1992)), the distribution of earnings noise $x$ is assumed to be known. The CEO and the compensation committee have perfect knowledge about the mean $\theta$ and the variance $\sigma^2$ of the earnings noise distribution. Thus, there is no estimation risk, which is defined as uncertainty about the parameters of the earnings noise distribution. Absent estimation risk, the only source of risk in earnings-based CEO cash pay contracts results from known variations in earnings noise $x$, which are captured by the variance $\sigma^2$.

In reality however, neither the CEO nor the compensation committee know the mean $\theta$ and the variance $\sigma^2$ of the earnings noise distribution. Therefore, this thesis examines the more general case when there is estimation risk. To simplify the analysis, it is assumed that the variance $\sigma^2$ of the earnings noise distribution is known. The mean $\theta$ of the earnings noise distribution is assumed to be unknown. The model in this thesis demonstrates that estimation risk resulting from the unknown mean of the earnings noise distribution affects earnings-based CEO cash pay, because the CEO is risk averse. Specifically, estimation risk will be shown to reduce the optimal sensitivity of CEO cash pay to earnings compared to the traditional setting where the distribution of earnings noise $x$ is known.

This thesis relies on a Bayesian framework to model how the CEO and the compensation committee learn about the unknown mean $\theta$ of the earnings noise distribution. To do so, the CEO and the compensation committee rely on past earnings to back out past earnings noise realizations. This backing out is possible because past earnings reflect both past CEO effort and past noise, and because the CEO and the compensation committee know the optimal past CEO effort from when they set CEO cash pay in previous years. In the principal-agent setting, the CEO always chooses the optimal effort. The CEO and the compensation committee use these past earnings noise realizations to update their beliefs and thus learn about the unknown mean $\theta$ of the earnings noise distribution. Learning occurs since past earnings noise realizations contain information about the unknown mean $\theta$.

The model in this thesis examines how the CEO's and the compensation committee's learning about the unknown mean $\theta$ of the earnings noise distribution affects the optimal weight on earnings. The analysis will show that while estimation risk leads to a lower weight on earnings, the magnitude of this effect declines with the record of past earnings noise realizations. As the record of past earnings noise observations becomes longer, these past earnings noise observations provide a more precise signal about the unknown mean $\theta$. The CEO and the compensation committee then learn to a larger extent and the impact of estimation risk on the weight on earnings is quite small. On the other hand, when the record of past earnings noise observations is short, these past earnings noise observations provide an imprecise signal about the unknown mean $\theta$ of the earnings noise distribution. Little learning occurs, and the impact of estimation risk on the weight on earnings is larger.

## 1.2 Agents and timeline of events

The model is for a single task and a single period, but with several stages, each one of which is described below.

1. At the beginning of the game, the firm has a CEO whose effort level $e$ is not observable. The CEO has constant absolute risk-averse (CARA) risk preferences represented by the negative exponential utility function $U(W) = -e^{-r(W-c[e])}$, where $r$ is the CEO's coefficient of risk aversion. CEO cash pay is given by $W$, and further detailed below. The personal cost to the CEO of providing effort $e$ is $c[e]$, where $c[\cdot]$ is a strictly convex function. The CEO chooses effort $e$ to maximize his expected utility, $E[U(W)]$, where the expectation is taken over his net cash pay for the year ahead.

2. The compensation committee, which is a perfect agent for risk-neutral shareholders, chooses the parameters of the CEO's cash pay contract for the year ahead. This contract takes the form $W = \alpha + \beta A$, where $W$ is cash pay, $\alpha$ is salary, $A$ is earnings for the year ahead, and $\beta$ is the weight on earnings.[1] The parameters of this contract are the salary $\alpha$ and the sensitivity $\beta$ of CEO cash pay to earnings. This thesis focuses its analysis on the sensitivity $\beta$ of CEO cash pay to earnings. Henceforth, when discussing the optimal contract, the thesis thus refers to the sensitivity $\beta$ of CEO cash pay to earnings. The impact of estimation risk on the salary $\alpha$ is briefly discussed later on.

[1] It is standard in the literature to assume a linear contract, mainly because of tractability (Lambert, 2001). The results in Holmström and Milgrom (1987) suggest that the linearity assumption is innocuous. Holmström and Milgrom (1987) examine a continuous time model in which the agent controls the drift rate of a Brownian motion. They show that the optimal solution to this model is equivalent to one in which the agent selects a single-period effort and the principal restricts himself to a linear contract.

3. The CEO and the compensation committee know that earnings $A$ for the year ahead are a noisy signal of CEO effort $e$, that is $A = e + x$, where $x$ is noise from a normally distributed population with mean $\theta$ and variance $\sigma^2$.[2] Contrary to the traditional principal-agent setting, the present model assumes that neither the CEO nor the compensation committee know the mean $\theta$ of the noise distribution. However, they know the form of the noise distribution (i.e. that it is normal), and its variance $\sigma^2$.

4. The CEO and the compensation committee have no prior information about the unknown mean $\theta$ of the earnings noise distribution. They learn in a rational manner about $\theta$. After observing $n$ independent past earnings noise realizations $x_1 ... x_n$, they use Bayes' rule to form a posterior distribution for $\theta$. Past earnings noise realizations are backed out from past earnings observations, since the optimal CEO effort $e$ is known and since earnings are the sum of CEO effort and earnings noise (see equation (1.1)). As argued in Lambert (2001), optimal CEO effort is known because when CEO cash pay is determined, it is as if both the optimal contract and the optimal CEO effort $e$ are set. Since the CEO will not chose an effort level other than the optimal one, the compensation committee knows CEO effort $e$. However, CEO effort is not observable, and hence the compensation committee cannot verify its conjecture about CEO effort.

---

[2] It is standard in the literature to assume that CEO effort only affects the mean of the earnings distribution. Sung (1995) relaxes this assumption. It is also standard in the literature to assume a normal distribution for the noise in earnings, and hence for earnings. Lambert (2001) argues that the primary advantage of the normality assumption is that CEO effort can affect the mean of the earnings distribution without affecting its higher moments. Dewatripoint et al. (1999) examine the impact of relaxing the normality assumption in the context of career concerns. Empirical evidence suggests that the assumption of a normal distribution for earnings may be problematic (Hayn, 1995; Basu, 1997; Gu and Wu, 2003).

5. Upon forming the posterior for the unknown mean $\theta$ of the earnings noise distribution, the CEO and the compensation committee update their beliefs about noise in year ahead earnings.

6. Given the updated beliefs about noise in next year's earnings, the CEO is offered a contract which he decides to accept or reject in favor of a reservation wage. The reservation wage is not specified, because the model focusses on the sensitivity $\beta$ of CEO cash pay to earnings. The reservation wage does not affect the combined payoff from CEO effort to the firm and the CEO, it only determines how this combined payoff is split, and thus impacts the salary $\alpha$.

## 1.3 Learning about the noise distribution

The distinguishing feature of the model in this thesis is that CEO and the compensation committee do not know the true mean $\theta$ of the earnings noise distribution. However, they learn about $\theta$ over time. Specifically, they update their prior beliefs about $\theta$ according to Bayes' rule. It is assumed that the CEO and the compensation committee have a common prior about the unknown mean $\theta$ that is uninformative.[3] This thesis examines informative priors later on, and shows that the main conclusions of its model hold.

The CEO and the compensation committee update their prior beliefs about the unknown mean $\theta$ of the earnings noise distribution after they observe past earnings noise realizations up until year $t-1$ (denoted by $x_n$), and form their posterior for $\theta$. The posterior for $\theta$ has a normal distribution with a mean $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$, which

[3]Uninformative priors can take several forms. The current thesis uses Jeffreys' prior, which has been shown to have certain desirable characteristics (Jeffreys, 1961). In statistical terms, the probability density function of Jeffreys' prior for $\theta$ is $p(\theta) \propto$ constant, where $\propto$ is the proportionality sign, and $-\infty < \theta < +\infty$.

is the sample mean of the $n$ past earnings noise observations available up to $t-1$ (Zellner, 1971; Lee, 1989). The variance $\sigma_1^2$ of the posterior distribution for $\theta$ is $\sigma_1^2 = \frac{\sigma^2}{n}$. The variance $\sigma_1^2$ decreases as the record of past earnings noise observations rises and $n$ becomes larger. Past earnings noise observations then provide a more precise signal about the mean $\theta$ of the earnings noise distribution. The CEO and the compensation committee learn about $\theta$, and will eventually know its true value (Chamley, 2004).[4]

Assuming a quadratic loss function, the Bayes point estimate $\hat{\theta}$ for the unknown mean $\theta$ is the mean of the posterior distribution, $\hat{\theta} = \bar{x}$ (Zellner, 1971; Robert, 1994). The variance of this point estimate $\hat{\theta}$, which is the smallest variance amongst all possible point estimates, is the variance of the posterior distribution for $\theta$, $\sigma_1^2$. Hence, as the number of past earnings noise observations grows, the CEO and the compensation committee can provide a more precise point estimate for $\theta$.

Upon forming their posterior for the unknown mean $\theta$, the CEO and the compensation committee update their beliefs about the distribution of noise in year ahead earnings. The noise in year ahead earnings is distributed normally, with a mean $\bar{x}$ and a variance $\sigma^2 + \frac{\sigma^2}{n} = \sigma^2(1 + \frac{1}{n})$ (see Appendix A for the formal proof). The variance $\sigma^2(1 + \frac{1}{n})$ of noise in next year's earnings includes not only the cause of risk traditionally examined in the literature, $\sigma^2$, but also an additional source of risk, namely estimation risk, given by the term $\frac{1}{n}$. As the number $n$ of past earnings noise observations increases, the impact of estimation risk on the variance of earnings noise declines. To illustrate, suppose that the CEO and the compensation

[4] In order to learn and eventually know the true value of the mean of the earnings noise distribution, it is necessary that the mean of this distribution is stationary. The thesis discusses in its section on the empirical predictions the case where the mean of the earnings noise distribution is not stationary and is affected by shocks.

committee observe two past earnings noise realizations ($n = 2$). The variance of the noise in next year's earnings is $\sigma^2(1 + \frac{1}{2}) = 1.5\sigma^2$, and is 50% higher than when there is no estimation risk. Now suppose the CEO and the compensation committee observe five past earnings noise observations ($n = 5$). The variance of noise in next year's earnings is then only 20% ($\sigma^2(1 + \frac{1}{5}) = 1.20\sigma^2$) higher than when there is no estimation risk. Estimation risk thus substantially increases the variance of noise in next year's earnings when the number $n$ of past earnings noise observations is small. However, in the limit, as the record of past earnings noise realizations becomes very long, estimation risk has a negligeable impact on the variance of noise in next year's earnings.

## 1.4 Optimal contract

Given the distribution of noise in year ahead earnings, the optimal contract can now be derived. This section follows Milgrom and Roberts (1992) who show that the optimal contract maximizes the combined certainty equivalent of the firm and the CEO, subject to the CEO's incentive compatibility constraint.[5] The following optimization problem thus obtains:

$$max_e CE_F + CE_{CEO} \tag{1.2}$$

subject to:

$$e \in argmax_e CE_{CEO} \tag{1.3}$$

[5]Maximizing the combined certainty equivalent of the CEO and the firm yields an efficient contract if the preferences of the CEO and the firm display no wealth effects (Milgrom and Roberts, 1992). The no wealth effects condition holds in the current setting. This happens because the preferences of the firm (which is risk neutral) and the CEO (who has CARA utility function) are such that the certainty equivalent of one of these parties can be increased by reducing the certainty equivalent of the other party by an equal amount, without changing the combined certainty equivalent.

where $CE_F$ is the firm's certainty equivalent, and $CE_{CEO}$ is the CEO's certainty equivalent. Since the firm is risk-neutral, its certainty equivalent equals its expected net payoff, $CE_F = E[p[e] - W]$, where $p[e]$ is the benefit of CEO effort $e$ that directly accrues to the firm, and $W$ is CEO cash pay. The CEO's certainty equivalent $CE_{CEO}$ can be used in the maximization problem, since the CEO has negative exponential utility, and since noise is normally distributed (Holmström and Milgrom, 1987). The CEO's certainty equivalent $CE_{CEO}$ is as follows.

$$CE_{CEO} = E[W] - c[e] - \frac{1}{2} r Var[W] \tag{1.4}$$

The variable $E[W]$ is the CEO's expected cash pay, $E[W] = \alpha + \beta(e + \bar{x})$, where $\bar{x}$ is the updated mean of the earnings noise distribution. The last term of the expression for the CEO's certainty equivalent in equation (1.4), $\frac{1}{2} r Var[W]$, is the CEO's risk premium. This risk premium depends on the CEO's coefficient of risk aversion $r$ and on the risk resulting from the CEO's cash pay, which is given by the variance of CEO cash pay $Var[W] = \beta^2 \sigma^2 (1 + \frac{1}{n})$, since variance of the noise in next year's earnings is $\sigma^2(1 + \frac{1}{n})$. Compared to the traditional principal-agent setting where the mean of the earnings noise distribution is known, the variance of CEO cash pay has an additional term, namely the ratio $\frac{1}{n}$, which reflects estimation risk. All else being equal, the CEO's risk premium $\frac{1}{2} r Var[W]$ is larger when there is estimation risk.

Maximizing the CEO's certainty equivalent in equation (1.4) with respect to effort $e$ yields $\beta = c'[e]$. The result that $\beta = c'[e]$ is substituted into the combined certainty equivalent of the firm and the CEO in equation (1.2). Maximizing this combined certainty equivalent with respect to effort $e$ yields the following optimal weight $\beta$ on earnings:

$$\beta = \frac{p'[e]}{1 + rc''[e]\sigma^2(1 + \frac{1}{n})}. \tag{1.5}$$

The optimal weight $\beta$ on earnings in equation (1.5) can be compared with the optimal weight on earnings when the mean $\theta$ of the earnings noise distribution is known. If $\theta$ is known, the weight $\beta$ on earnings is $\frac{p'[e]}{1+rc''[e]\sigma^2}$. The only source of risk that then affects $\beta$ is the variance of earnings noise $\sigma^2$. On the other hand, when $\theta$ is not known, risk affects $\beta$ both through the variance of earnings noise $\sigma^2$, as when $\theta$ is known, and through estimation risk $\frac{1}{n}$. Compared to the traditional setting where the mean of the earnings noise distribution is known, the weight on earnings is thus lower if there is estimation risk. As the record $n$ of past earnings noise observations becomes longer, the optimal weight $\beta$ on earnings when the mean $\theta$ of the earnings noise distribution is not known approaches the optimal weight $\beta$ when the mean $\theta$ is known. However, if the record of past earnings noise observations is short, estimation risk can substantially affect the optimal weight $\beta$. Specifically, the optimal weight $\beta$ decreases as the number $n$ of past earnings noise observations becomes smaller. Hence the main prediction of this thesis is that the weight on earnings declines with estimation risk.

Furthermore, the optimal weight $\beta$ in equation (1.5) illustrates how estimation risk is different from the traditional sources of risk already examined in the literature (Lambert and Larcker, 1987; Sloan, 1993). These sources of risk focus on the variance $\sigma^2$ of the earnings noise distribution, which reflects variation in earnings noise about the *known* mean of the earnings noise distribution. Estimation risk adds the term $\frac{1}{n}$ in the denominator of equation (1.5) and thus captures additional variation that arises because the mean of the earnings noise distribution is *unknown*. Hence, estimation risk is a cause of risk that is incremental to the sources of risk already analyzed in the literature.

## 1.5 Extensions

The basic model used above can be augmented in three ways.

- First, the model can allow for a different prior about the mean of the earnings noise distribution. Recall that the model assumes a uninformative prior. Although such priors are commonly used, they can be problematic (see for instance Zellner (1971), Lee (1989), and Robert (1994)). Hence, the assumption of an uninformative prior is dropped. Instead, suppose that the CEO and the compensation committee have a common informative prior that the unknown mean $\theta$ is normally distributed with a mean $\theta_0$ and variance $\sigma_0^2$. There are various sources of prior information, such as expertise resulting from prolonged years of service on the compensation committee, or information from similar firms in the industry. Appendix B shows that in the presence of such an informative prior, estimation risk rises when the number $n$ of past noise realizations is smaller, just as in the case with an uninformative prior. Furthermore, estimation risk also increases when the variance of the prior $\sigma_0^2$ is larger. The optimal weight $\beta$ on earnings decreases as estimation risk becomes more important. Hence the main prediction of the model in this thesis holds in the absence of an uninformative prior.

- Second, the model can specify a reservation wage $\underline{w}$. The CEO accepts the proposed CEO cash pay contract if his certainty equivalent is at least equal to the reservation wage $\underline{w}$, otherwise he rejects it. Given a reservation wage $\underline{w}$, the optimal salary is $\alpha = \underline{w} - \frac{p'[e]}{1+rc''[e]\sigma^2(1+\frac{1}{n})}(e+\bar{x}) + c[e] + \frac{1}{2}r(\frac{p'[e]}{1+rc''[e]\sigma^2(1+\frac{1}{n})})^2\sigma^2(1+\frac{1}{n})$. Estimation risk affects the optimal salary $\alpha$ in two ways. First, estimation risk impacts expected CEO cash pay $E[W]$. Higher estimation risk lowers the part of incentive pay (given by $\beta E[A]$) in expected CEO cash pay $E[W]$. All else being equal, the firm then has to pay the CEO a higher salary in order to meet the CEO's reservation utility. Second, estimation risk affects the optimal salary $\alpha$ though the CEO's risk premium $\frac{1}{2}r\beta^2\sigma^2(1+\frac{1}{n})$, in two opposing ways. All else being equal, higher estimation risk raises the riskiness of CEO cash pay, since $\sigma^2(1+\frac{1}{n})$ increases. A risk averse CEO then requires a higher risk premium, and salary rises. However, this effect is offset by the fact that the CEO's risk premium depends on the optimal weight $\beta$. When estimation risk rises, the optimal weight $\beta$ falls, which then lowers the CEO's risk premium and hence salary. The overall impact of estimation risk on salary depends on which of the three effects discussed above dominates. In the limit, as estimation risk becomes very high, the salary equals $\alpha = \underline{w} + c[e]$.

- Third, the model can include a performance standard $S$. Performance standards define the level of earnings required for the CEO to be awarded a bonus. They are increasing in expected earnings $E[A] = e + \bar{x}$ (Murphy, 2000).[6] The updated mean $\bar{x}$ of distribution for noise in year ahead earnings thus directly affects the performance standard.

[6] Although performance standards increase with expected earnings, compensation committees are unlikely to set performance standards equal to expected earnings if they want to compensate the CEO for delivered performance (Barclay et al., 2005), decrease the CEO's earnings management incentives or prevent the CEO from being demotivated.

## 1.6 Empirical predictions

The empirical predictions focus on the model's main insight that the weight on earnings falls when estimation risk rises. The model assumes that the mean of the earnings noise distribution is constant through time. Estimation risk is then lower for older firms. In reality, the assumption of a stationary earnings noise distribution is unlikely to hold. For example, a shock could affect the mean of the earnings noise distribution. The CEO and the compensation committee then have to learn about the new mean of the earnings noise distribution. Over time, they update their prior about the new mean of the earnings noise distribution using earnings noise observations from the earnings noise distribution with the new mean. Thus, when the noise distribution is not stationary, the CEO and the compensation committee have to start the learning process anew whenever the earnings noise distribution changes.

Given that the earnings noise distribution likely changes through time, this thesis uses two proxies to test the model's main prediction that the weight on earnings falls with estimation risk. The first estimation risk proxy is the dispersion of analysts' forecasts for next year's earnings. Analysts have been shown to act as information intermediaries who retransmit information to investors (Lang and Lundholm, 1996), and as information providers (Womack, 1996; Frankel et al., 2006). Analysts obtain current and past information about the firm from numerous sources, such as published financial statements, press releases, industry reports, other analysts' forecasts, or conference calls (O'Brien, 1988). The amount of information available to analysts likely correlates with the number of past earnings noise observations used by the CEO and the compensation committee to learn about the mean of the earnings noise distribution.

When the CEO and the compensation committee have a shorter record of past earnings noise observations for learning, analysts too likely have less information to forecast next year's earnings. Analysts' opinions then diverge to a larger extent, and the dispersion of their forecasts for next year's earnings rises (Barry and Brown, 1985). This argument is supported by evidence suggesting that if analysts have more information, they learn and improve their forecasts (Mikhail et al., 1997; Clement, 1999; Markov and Tamayo, 2006). Hence when the CEO and the compensation committee face higher estimation risk, the dispersion of analysts' forecasts for next year's earnings likely is larger too. The weight on earnings is therefore expected to decline as the dispersion of analysts' forecasts for year ahead earnings increases. The dispersion of analysts' forecasts may correlate not only with estimation risk, but also with the known variability of earnings noise ($\sigma^2$ in equation (1.5)), which is the source of risk traditionally examined in the literature (Lambert and Larcker, 1987; Sloan, 1993). Control variables for $\sigma^2$ are thus included in the empirical analysis.

*Hypothesis 1. Ceteris paribus, the sensitivity of CEO cash pay to earnings declines as the dispersion of analysts' forecasts for the year ahead earnings increases.*

The second estimation risk proxy is economic shocks. Contemporaneous and past shocks likely affect the mean of the next year's earnings noise distribution since earnings are not timely (Beaver et al., 1980; Warfield and Wild, 1992; Collins et al., 1994).[7] Shocks can occur because of events in the firm's operating environment, such as the entry of a new competitor. The CEO and the compensation committee likely have two pieces of information about such shocks. First, the CEO

[7] Appendix C explains why earnings are not timely.

and the compensation committee likely know about the existence of shocks when they set CEO cash pay for the year ahead, because they can observe the shocks. This argument is supported by the fact that stock market participants recognize shocks, since shocks are impounded in a timely manner in returns. Second, the CEO and the compensation committee likely know whether or not shocks impact year ahead earnings, because of their experience in the firm. In the current setting, the CEO and the compensation committee are thus able to identify shocks that affect the mean of next year's earnings noise distribution. However, the CEO and the compensation committee do not know a shock's effect on the mean of the earnings noise distribution. Rather, they learn over time about a shock's impact on the mean of the earnings noise distribution. In order to learn, the CEO and the compensation committee look at how similar past shocks have affected past earnings noise.

Similar past shocks provide a more precise signal about the new mean of the earnings noise distribution when there is a longer record of how these past shocks have affected past earnings noise. Economic shocks occur less often as they become larger (Balke and Fomby, 1991, 1994). The firms examined in this thesis confirm this pattern of larger shocks being rarer, since the mode of the sample firms' stock returns is 0%. Hence, as shocks become larger, the CEO and the compensation committee likely have a shorter record of how similar past shocks have affected past earnings noise. There is less learning, and estimation risk rises.[8]

The size of shocks is captured using the absolute value of stock returns, since

[8]A similar argument can be made using the CEO's and the compensation committee's prior information instead of their learning process. Recall from the analysis in Appendix B that, in the case of an informative prior, estimation risk increases when the variance of the CEO's and the compensation committee's prior is higher. When shocks to the mean of the noise distribution are larger and occur less often, the CEO and the compensation committee likely are more uncertain about the effect of this shock on the mean of the noise distribution and have common prior with a higher variance. Estimation risk is then larger too, so that the weight on earnings falls.

returns reflect shocks in a timely manner, and since the absolute value abstracts away from the sign of the shocks. Although the argument above is for shocks from $t-1$ that affect mean earnings noise in $t$, it readily extends to shocks from prior to $t-1$ that impact mean earnings noise in $t$. This thesis then predicts that the weight on earnings is smaller when the absolute value of past returns rises. The size of economic shocks likely affects not only the number of observations used to learn about the new mean of the noise distribution but also the variance $\sigma^2$, which captures known variation in year $t$ earnings noise due to shocks from $t-1$. Control variables for $\sigma^2$ are therefore included in the empirical analysis.

*Hypothesis 2. Ceteris paribus, the sensitivity of CEO cash pay to earnings declines as the absolute value of past stock returns increases.*

Economic shocks can affect earnings noise during several years, as suggested by evidence that earnings relate positively to past returns, going back three years (Collins et al., 1994). Earnings reflect both permanent and temporary shocks (Ali and Zarowin, 1992; Burgstahler et al., 2002). The length of time during which a shock impacts earnings depends on accounting rules and economic factors such as competition (Lev, 1983). For a given shock that affects earnings noise during several years, the record of how this particular shock has already impacted past earnings noise then becomes longer over time. Hence the number of observations available to the CEO and the compensation committee for learning about the new mean of the earnings noise distribution grows as time goes by, and estimation risk falls.

To illustrate this argument, suppose a shock from $t-1$ affects the mean of the earnings noise distribution between $t$ and $t+2$. For example, the firm wins a new contract in $t-1$ that provides additional sales between $t$ and $t+2$. In $t+1$, when the parameters of CEO cash pay for $t+2$ are set, the CEO and the compensation committee can already observe how the shock from $t-1$ has affected earnings noise in $t$ and in $t+1$. The number of past observations used to learn about the mean of the year $t+2$ earnings noise distribution is then higher than the number of past observations used to learn about the mean of the year $t+1$ earnings noise distribution. Therefore, the weight on earnings in $t+2$ is higher than the weight on earnings in $t+1$. Hence the following prediction obtains.

*Hypothesis 3. Ceteris paribus, the sensitivity of CEO cash pay to earnings is lower for more extreme returns from the more recent past than for more extreme returns from the more distant past.*

The model in this thesis considers earnings as the performance measure used in CEO cash pay plans. In reality, CEO cash pay is based on a variety of performance measures. These multiple performance measures include, in addition to earnings, non-financial performance measures such as customer satisfaction, product and service quality as well as strategic objectives (Ittner et al., 1997). Furthermore, firms frequently adjust earnings and non-financial performance measures subjectively ex post (Baiman and Rajan, 1995; Bushman et al., 1996; Murphy and Oyer, 2003). In the context of multiple performance measures, researchers analyze the relative weight of two performance measures (see for instance Banker and Datar (1989)). The relative weight on two performance measures is defined as the ratio of the absolute weight on two performance measures, such as the ratio of the weight on customer satisfaction to the weight on earnings.

In a simple single-task framework such as the model in this thesis, the relative weight on two performance measures is affected by the sensitivity of each performance measure to the CEO's action, the variance of the noise in each performance measure and the correlation between the noise in each performance measure (Banker and Datar, 1989; Sloan, 1993). If the correlation between the noise in each performance measure is zero, an increase in the variance of the noise in one performance measure results in a higher relative weight on the other performance measure. Intuitively, as one performance measure becomes riskier, the relative weight is shifted towards the other performance measure, since the CEO is risk averse. If the correlation between the noise in each performance measure is not zero, an increase in the variance of the noise in one performance measure still leads to a higher relative weight on the other performance measure under fairly general conditions (Sloan, 1993). Hence, an increase in estimation risk about the distribution of earnings noise is expected to result in a larger relative weight on the non-financial performance measure. Furthermore, the relative weight on the subjective performance measure is also expected to increase. Intuitively, compensation committees may not want to set the weight on earnings objectively ex ante when there is estimation risk, since they cannot precisely estimate the mean of the earnings noise distribution. Rather, compensation committees may prefer to evaluate the CEO's contribution to earnings subjectively after having observed next year's earnings, in order to mitigate estimation risk. Consistent with this argument, Murphy and Oyer (2003) contend that subjective performance measures are useful to mitigate risk in objective performance measures ex post.

The single-task framework is restrictive because it assumes that the CEO engages in one single activity. In reality, CEOs engage in a variety of activities. CEOs can vary the effort that they spent on activities such as generating revenues versus increasing customer satisfaction. Different activities do not necessarily affect all performance measures to the same extent. For instance, earnings can be thought of as capturing short-term activities, while not reflecting the effect of long-term activities such as customer service. In a multi-task framework, compensation committees consider how the CEO allocates his effort across various activities. Multi-task agency models show that, compared to single-task models, the effect of risk on the relative weight on two performance measures depends in addition on how sensitive the various performance measures are to the different CEO activities, and on how congruent the performance measures are with each other and with firm value (Datar et al., 2001; Lambert, 2001). For instance, suppose the firm uses two performance measures, earnings and a non-financial performance measure such as customer satisfaction. When estimation risk about earnings noise rises, compensation committees have to balance the decrease in the relative riskiness of the non-financial performance measure with the congruence of the non-financial performance measure. Compensation committees then do not necessarily increase the weight on the non-financial performance measure, because this may induce distortive CEO behavior. The CEO could shift his effort towards activities that affect the relatively less noisy non-financial performance measure but that do not increase firm value. In this case, the firm may prefer to evaluate the CEO's contribution to the non-financial performance measure in a subjective manner, in order to mitigate distortive CEO behavior (Baker et al., 1994)

The only case where a clear prediction can be made about the effect of estimation risk on the relative weight on two performance measures is if these performance measures are perfectly congruent with each other. In that case, the weight on the performance measures does not affect the allocation of CEO effort across activities. The effect of risk on the relative weight on two performance measures is then the same as in the single-task framework (Datar et al., 2001). Hence, when estimation risk about earnings noise increases, the relative weight on non-financial and subjective performance measures rises. Thus the following testable prediction obtains.

*Hypothesis 4. Ceteris paribus, the relative weight on subjective or non-financial performance measures increases following large economic shocks.*

# Chapter 2

# Empirical analysis of how estimation risk affects CEO cash pay

## 2.1 Data

CEO compensation data from 1992 to 2004 is obtained from Standard & Poor's EXECUCOMP database. The firms included in EXECUCOMP are in the S&P500, the S&P mid cap 400, and the S&P small cap 600. Accounting data is from COMPUSTAT, and return data is from the monthly CRSP files. The sample selection is outlined in Table G.1. The main sample starts with 2,452 firms (21,877 firm-years) with data on CEO pay available on EXECUCOMP. After eliminating observations where the CEO is in office for a partial fiscal year, 2,417 firms (16,986 firm-years) remain. Requiring the CEO be in office for at least two fiscal years ensures that full year compensation is available but further reduces the sample to 2,352 firms (14,983 firm-years). Instances where an executive serves as the CEO of more than one firm per year, as well as instances where a firm has more than one CEO at the same time are discarded, resulting in 2,335 firms (14,717 firm-years). Firms are required to have data available on earnings before extraordinary items and discontinued operations (COMPUSTAT #18), the main earnings measure in this thesis.

This requirement leaves 2, 333 firms (14, 700 firm-years). Finally, firms need to have data on stock returns from CRSP for at least 24 consecutive months (to compute some of the control variables used in the empirical analysis), resulting in 2, 318 firms (14, 571 firm-years). To allow for a proper calculation of fiscal year returns, 13 observations with fiscal year end changes are discarded, which leaves 2,318 firms (14,558 firm-years). Finally, firms need to have cumulative monthly return data available by fiscal year. This last requirement leads to a final sample of 2,315 firms (14,463 firm-years).

## 2.2 Empirical specification

To test its first three hypotheses, this thesis uses the following regression for firm $i$ in fiscal year $t$.

$$\begin{aligned} C_{i,t} &= a_0 + b_0 A_{i,t} + \beta A_{i,t}\Lambda + \gamma\Lambda + \Omega A_{i,t} CV \\ &\quad + h_0 r_{i,t} + h_\tau r_{i,t-\tau} + \Gamma K + \varepsilon_{i,t} \end{aligned} \tag{2.1}$$

The variable $C_{i,t}$ is the natural logarithm of the level of either CEO cash pay or CEO bonus pay earned during fiscal year $t$. The natural logarithm is used to control for skewness in compensation data. CEO cash pay is the sum of bonus pay and salary. Table G.2 provides descriptive statistics on CEO pay. Average CEO cash pay is \$1, 025, 000, with an average CEO salary (bonus) of \$497, 000 (\$529, 000). $A_{i,t}$ is earnings, defined as income before extraordinary items and discontinued operations (COMPUSTAT #18) scaled by prior-year total assets (COMPUSTAT #6). Table G.2 shows that average (median) earnings are 4.3% (5.0%) of beginning-of-period total assets. The slope coefficient $b_0$ in equation (2.1) captures the weight on earnings when the proxy for estimation risk $\Lambda$ and the control variables $CV$ for the weight on earnings are zero. CEO pay and earnings are expected to be positively related (Lambert and Larcker, 1987; Natarajan, 1996), so that $b_0 > 0$.

The variable $\Lambda$ captures the two proxies for estimation risk, $Disp_{i,t-1}$ and $||r_{i,t-\tau}||$. The variable $Disp_{i,t-1}$ is the standard deviation of analysts' forecasts made in fiscal $t-1$ for earnings in fiscal $t$, scaled by the absolute average forecasts made in $t-1$ for earnings in $t$ (Healy et al., 1999). Data for analysts forecasts is obtained from the I/B/E/S Detail History File. Forecasts for year $t$ earnings are retained only if they were made during $t-1$. Since each analyst may make more than one forecast in $t-1$, only the most recent forecast is kept for every analyst (O'Brien, 1988). The standard deviation of the forecasts across all analysts, by firm and fiscal year is then calculated, and retained only if there are more than three analysts, in order to have a reliable measure of the dispersion of analysts' forecasts.

The variable $||r_{i,t-\tau}||$ measures the magnitude of past economic shocks, independent of their sign. It is the absolute value of market-adjusted returns from fiscal year $t-\tau$, with $\tau$ equal to 1, 2, or 3. The study relies on market-adjusted returns because it is interested in shocks that affect earnings. Market-wide movements such as changes in discount rates are unlikely to be recognized in earnings (Sloan, 1993) in the short term, although in the long run they affect earnings. The results of this thesis are robust to using raw returns rather than market-adjusted returns, as discussed in Section 3.3.

The two estimation risk proxies $Disp_{i,t-1}$ and $||r_{i,t-\tau}||$ are ranked across all firms. This ranking allows for a straightforward interpretation of the results, which are qualitatively the same if no ranking is used. For instance, when the standard deviation of analysts' forecasts is most (least) extreme and $Disp_{i,t-1} = 1$ ($Disp_{i,t-1} = 0$), the incremental sensitivity of CEO pay to earnings is $b_1 A_{i,t} \times 1$ ($b_1 A_{i,t} \times 0$). Furthermore, the ranking addresses potential homogeneity problems in the raw data. For instance, the 90th percentile of the standard deviation of analysts' forecasts is about 20 times larger than the 10th percentile. The slope coefficient $\beta$ in equation (2.1) captures the effect of $Disp_{i,t-1}$ and $||r_{i,t-\tau}||$ on the sensitivity of CEO pay to earnings. Higher estimation risk is expected to lead to a lower weight on earnings, implying that $\beta < 0$ since estimation risk is larger when the dispersion of analysts forecasts $Disp_{i,t-1}$ and the absolute value of past returns $||r_{i,t-\tau}||$ is higher. Furthermore, the effect of estimation risk on salary is unclear, so that no prediction is made for $\gamma$.

Control variables for the weight on earnings are captured by $CV$. Factors such as growth options (Smith and Watts, 1992), earnings persistence (Baber et al., 1998), CEO stock ownership (Sloan, 1993), and CEO tenure (Gibbons and Murphy, 1992) affect the sensitivity of CEO cash pay to earnings. The economic argument for considering these variables is further developed in Appendix E. More importantly, the study includes a control variable, $Risk_{i,t}$, for risk in earnings other than estimation risk (i.e. $\sigma^2$ in equation (1.5)). $Risk_{i,t}$ is based on Lambert and Larcker (1987), and is defined as the ranked ratio of the variance of earnings $A_{i,t}$ to the variance of returns $r_{i,t}$. Both variances are calculated over the five years prior to the sample year. Section 2.6 examines additional proxies for risk in earnings other than estimation risk, and shows that the results of this thesis hold. Appendix D details the computation of all of the above control variables, while Table G.2 provides some summary statistics for them.

The variable $r_{i,t}$ is returns, defined as annual market-adjusted stock returns for the fiscal year, computed by cumulating monthly market-adjusted returns. Returns are controlled for because they are sometimes used as an explicit performance measure in CEO cash pay contracts (Murphy, 2000). Moreover, firms rely on non-accounting performance measures such as customer satisfaction (Murphy, 1999; Ittner et al., 1997), as well as individual performance measures (Bushman et al., 1996). To the extent that information about non-accounting and individual performance measures is reflected in stock prices, CEO cash pay is positively related to returns. Table G.2 shows that average (median) returns are 3.5% (0.0%). $h_0$ captures the impact of contemporaneous returns on CEO cash pay. Since firms with higher stock returns pay larger cash compensation to their CEOs (Murphy, 1999), $h_0$ is expected to be positive.

The variable $r_{i,t-\tau}$ is returns from $t - \tau$. $h_\tau$ captures the effect of past returns $r_{i,t-\tau}$ on CEO cash pay. Past returns impact CEO cash pay for several reasons. First, past returns affect the performance standard, which is a function of expected earnings (Murphy, 2000). Because earnings lack timeliness, expected earnings reflect past shocks already captured in past returns. Larger past returns then imply higher expected earnings, and thus a higher performance standard. A higher performance standard results in lower CEO cash pay, so that the relation between CEO cash pay and past returns is negative.

From a theoretical perspective, this predicted negative relation between CEO cash pay and past returns can be offset by two additional factors. First, uncertainty about CEO ability is resolved over time (Holmström, 1979). CEOs who are more talented likely have created firm value in the past, and receive larger current cash pay (Murphy, 1986). Second, firms oftentimes compensate CEOs for past performance, because anticipated future pay for contemporaneous performance provides incentives to CEOs (Murphy, 1986). Hence both revelation of CEO ability and compensation for past performance imply a positive relation between CEO cash pay and past returns, whereas the adjustment of performance standards for past shocks results in a negative association between CEO cash pay and past returns.[1] Thus, this study makes no prediction for the relation between CEO cash pay and past returns.

Control variables for the level of CEO cash pay are given by $K$. The literature shows that it is important to control for firm characteristics such as size (Murphy, 1999), growth options (Smith and Watts, 1992), firm risk (Aggarwal and Samwick, 1999), and the number of board meetings, as well as for CEO characteristics such as CEO stock ownership (Core et al., 1999), CEO tenure (Deckop, 1988), the presence of a CEO who is chairman of the board of directors (Core et al., 1999), and the presence of an interlocked CEO. The reasons for including these variables are discussed in Appendix F. Appendix D details the computation of these variables.

Equation (2.1) is estimated using fixed effects estimation in order to control for unobservable factors that vary across CEOs and time, and that likely affect CEO pay (Murphy, 1985).[2] Examples of such unobservable factors include CEO characteristics such as education, training and responsibilities of the CEO. Fixed effects estimation implies subtracting from each variable the mean of the variable

[1] A fourth element that can affect the association between CEO cash pay and past returns is the date at which the CEO earns his cash pay. This study uses CEO bonus pay and CEO salary earned during the contemporaneous fiscal year. However, salary is oftentimes set at the beginning of $t$ based on firm performance in $t-1$, which could lead to a positive relation between CEO cash pay and past returns.

[2] The current study excludes observations where the absolute value of the studentized residual in the main regression in (2.1) is larger than four. This procedure is done when the estimation risk proxy is the dispersion of analysts' forecasts $Disp_{i,t-1}$, and when it is the absolute value of past stock returns $||r_{i,t-\tau}||$. About to 55 observations (or about 0.5% of the total sample) are thus eliminated. The adjusted R-square triples and the F-value of the regression nearly quadruples when these outliers are excluded. Belsley et al. (1980) and Greene (1997) indicate that observations with studentized residuals larger than two are potentially problematic and do not conform to the estimated model. The main results of this study hold when the outliers are not excluded from the sample.

by CEO as well as the mean of the variable by fiscal year, and adding back the grand mean of the variable across all observations, before estimating the regression by OLS.[3] Section 3.3 discusses an alternative method to fixed effects estimation, the first difference specification, and shows that the results hold.

Table G.3 presents the correlation coefficients for the variables in regression (2.1). The correlations between the two estimation risk proxies suggest that they capture a similar underlying factor, estimation risk. For instance, the correlation between $Disp_{i,t-1}$ and $||r_{i,t-1}||$ is significantly positive, at 0.16 ($p$-value $< 0.01$). Some of the correlations in Table G.3 are fairly large, such as the correlation between the two estimation risk proxies and return volatility $Vol_{i,t}$. For example, the correlation between $||r_{i,t-1}||$ and return volatility $Vol_{i,t}$ is 0.35 ($p$-value $< 0.01$). Return volatility can affect the sensitivity of CEO cash pay to earnings in two offsetting ways. First, higher return volatility suggests that stock returns include more risk from market movements, and/or more idiosyncratic risk. Hence as stock price volatility increases, the relative weight on returns falls, and the relative weight on earnings rises (Sloan, 1993). Second, return volatility correlates with earnings volatility, because of the positive relation between earnings and returns (Collins et al., 1994). Hence, higher return volatility suggests that earnings themselves are more volatile and include more risk from market movements, and/or more idiosyncratic risk. Furthermore, the parameters of the earnings noise distribution are then more difficult to estimate,

[3]Fixed effects analysis yields consistent and unbiased estimators. It also consistently estimates the population-average slope coefficients in panel data models with individual-specific slopes under fairly weak assumptions (Wooldridge, 2005). Fixed effects estimation is preferred to random effects estimation if the individual CEO and year effects are correlated with the other independent variables, such as firm performance, which is likely to be the case (Deckop, 1988). Random effects estimation assumes that the individual effects are not correlated with the regressors (Wooldridge, 2005). If such correlation exists, random effects estimation is biased and inconsistent because it puts the individual effects into the error term, whereas fixed effect estimates are unbiased and consistent (Deckop, 1988).

thus increasing estimation risk. Thus, as return volatility increases, the relative weight on earnings falls.

Because the two estimation risk proxies correlate positively with return volatility, they may reflect sources of risk other than estimation risk that are captured by return volatility and that affect the sensitivity of CEO cash pay to earnings. To address this possibility, this thesis uses two control variables for return volatility: the proxy for risk in earnings relative to risk in returns proposed by Sloan (1993) (described in Section 2.6), and return volatility $Vol_{i,t}$ (discussed in Section 3.3). Finally, this thesis controls for earnings risk other than estimation risk, as described in Section 2.6. The main results of the study generally hold. However if the empirical constructs for sources of risk other than estimation risk do not adequately control for such sources of risk, the two estimation risk proxies used in this thesis may capture not only estimation risk, but also sources of risk other than estimation risk.

## 2.3 Test of Hypothesis 1

To test Hypothesis 1, the empirical specification in equation (2.1) is adapted as follows.

$$\begin{aligned} C_{i,t} &= a_0 + b_0 A_{i,t} + \mathbf{b_1 A_{i,t} Disp_{i,t-1}} + c_1 Disp_{i,t-1} + g_1 A_{i,t} B/M_{i,t} \\ &\quad + g_2 A_{i,t} Noise_{i,t} + g_3 A_{i,t} \psi_i + g_4 A_{i,t} Own_{i,t} + g_5 A_{i,t} Tenure_{i,t} \\ &\quad + h_0 r_{i,t} + h_\tau r_{i,t-\tau} + \Gamma K + \varepsilon_{i,t} \end{aligned} \tag{2.2}$$

The slope coefficient $b_1$ captures the effect of analysts' forecast dispersion $Disp_{i,t-1}$ on the sensitivity of CEO pay to earnings. Hypothesis 1 predicts that the weight on earnings declines as the dispersion of analysts' forecasts for the year ahead earnings increases. Hence it is expected that $b_1 < 0$.

### 2.3.1 CEO cash pay

Table G.4 displays the results from estimating regression (2.2) for CEO cash pay in column (1). To simplify the presentation, the coefficients on the control variables in $\Gamma$ for the level of CEO cash pay are not displayed. The $t$-statistics (in parentheses) are corrected for heteroscedasticity. The evidence strongly supports Hypothesis 1 and shows that the weight on earnings falls as the dispersion of analysts' forecasts increases. The coefficient $b_1$ on earnings interacted with the dispersion of analysts' forecasts $A_{i,t}Disp_{i,t-1}$ is significantly negative at $b_1 = -0.460$ ($t$-statistic of $-3.19$). This result suggests that when analysts are more uncertain about future earnings, estimation risk is higher too, and the weight on earnings declines. For the most extreme dispersion of analysts' forecasts ($Disp_{i,t-1} = 1$), the weight on earnings is $0.948 - 0.460 \times 1 + 0.308 \cong 0.796$, where 0.308 is the sum of the coefficients $g_1$ through $g_5$ on earnings $A_{i,t}$ interacted with the control variables for the pay-performance sensitivity to earnings.[4] For every 10% increase in earnings, CEO cash pay rises by about 8.0%, or \$81,600 when applied to average CEO cash pay of \$1,025,000 from Table G.2. For the lowest dispersion of analysts' forecasts ($Disp_{i,t-1} = 0$), the weight earnings is $0.948 - 0.460 \times 0 + 0.308 \cong 1.256$. For every 10% increase in earnings, CEO cash pay rises by about 12.6%, or \$128,750. This analysis indicates that the sensitivity of CEO cash pay to earnings varies widely for various levels of analysts' forecast dispersion, with the weight on earnings being about 58% ($= \frac{\$128{,}750 - \$81{,}600}{\$81{,}600}$) higher for the lowest dispersion of analysts' forecasts than for the highest dispersion. Finally, the coefficient $c_1$ on $Disp_{i,t-1}$ is significantly positive, indicating that CEOs receive higher salaries when estimation risk is larger.

[4] $0.308 \cong (0.432)(0.71) + (-1.040)(0.49) + (0.443)(0.70) + (-0.032)(-5.25) + (0.017)(1.96)$, where 0.71, 0.49, 0.70, $-5.25$ and 1.96 are the average values for $B/M_{i,t}$, $Risk_{i,t}$, $\psi_i$, $Own_{i,t}$ and $Tenure_{i,t}$.

The evidence for the control variables for the weight on earnings generally support the predictions. Firms with less growth options (and higher $B/M_{i,t}$) raise the weight on earnings. This finding is consistent with the argument in Smith and Watts (1992) that earnings are more informative about CEO actions when firms have less growth options. As earnings risk $Risk_{i,t}$ rises, the weight on earnings falls, consistent with Lambert and Larcker (1987). The difference between estimation risk and $Risk_{i,t}$ is further discussed in Section 2.6. The sensitivity of CEO cash pay to earnings increases with earnings persistence $\psi_i$, as in Baber et al. (1998). This evidence suggests that firms use cash pay contracts that encourage CEOs to look beyond the contemporaneous year, and thus extend the CEO's decision horizon. Finally, firms whose CEO owns a larger percentage of the firm lower the weight on earnings. This results is consistent with the argument that CEOs with high stockholdings receive less of other types of incentive pay because large stockholdings already provide strong incentive pay (Sloan, 1993).

The evidence in Table G.4 also shows that CEO cash pay is positively related to contemporaneous and past returns. For instance, the coefficient $h_1$ on returns from $t-1$ is 0.155 ($t$-statistic of 13.71) in column (1), consistent with the literature that documents a positive association between CEO cash pay and past returns (Joskow and Rose, 1994; Brennan and Subramanyam, 1995). This result suggests that factors such as the revelation of CEO ability and the compensation for past firm performance are more important in determining the relation between CEO cash pay and past returns than the adjustment of performance standards for past shocks. Evidence in Murphy (1986) suggests that revelation of CEO ability plays a substantial role in CEO cash pay contracts (more so than the compensation for past firm performance).

### 2.3.2 CEO bonus pay

The results for CEO bonus pay, which are shown in column (2) of Table G.4, are qualitatively similar to the findings for CEO cash pay in column (1) and support Hypothesis 1. The evidence indicates that the coefficients $b_1$ on earnings interacted with analysts' forecast dispersion $A_{i,t}Disp_{i,t-1}$ is significantly negative at $b_1 = -2.79$ ($t$-statistic of $-3.53$). In terms of economic significance, the results for CEO bonus pay are also similar to the findings for CEO cash pay. When analysts' forecast dispersion in $t-1$ is highest (and $Disp_{i,t-1} = 1$), the sensitivity of CEO bonus pay to earnings is 5.37.[5] For every 10% increase in earnings, CEO bonus pay increases by about 53.7%, which translates into a rise of \$283,950 when using the average CEO bonus pay of \$529,000 from Table G.2. A 10% increase in earnings has a much bigger dollar effect on CEO bonus pay than on CEO cash pay. The differential effect occurs because CEO bonus pay is the portion of CEO cash pay that is most sensitive to earnings. When analysts' forecast dispersion in $t-1$ is lowest (and $Disp_{i,t-1} = 0$), the weight on earnings is 8.16.[6] For every 10% increase in earnings, CEO bonus pay rises by 81.6%, or \$431,540. The sensitivity of CEO bonus pay to earnings is thus about 52% ($= \frac{\$431{,}540-\$283{,}950}{\$283{,}950}$) higher when analysts' forecast dispersion in $t-1$ is lowest rather than highest.

[5] $5.37 \cong 7.73 - 2.79 \times 1 + 0.43$, where 0.43 is the sum of the coefficients $g_1$ through $g_5$ on earnings $A_{i,t}$ interacted with the control variables for the weight on earnings, with the control variables taken at their mean values.

[6] $8.16 \cong 7.73 - 2.79 \times 0 + 0.43$, where 0.43 is the sum of the coefficients $g_1$ through $g_5$ on earnings $A_{i,t}$ interacted with the control variables for the weight on earnings, with the control variables taken at their mean values.

## 2.4 Test of Hypothesis 2 and Hypothesis 3

This section tests both Hypothesis 2 and Hypothesis 3, using the following specification adapted from equation (2.1).

$$\begin{aligned} C_{i,t} = {} & a_0 + b_0 A_{i,t} + \sum_{\tau=1}^{\tau=3} \mathbf{b}_\tau \mathbf{A}_{\mathbf{i,t}} ||\mathbf{r}_{\mathbf{i,t-\tau}}|| + \sum_{\tau=1}^{\tau=3} c_\tau ||r_{i,t-\tau}|| + g_1 A_{i,t} B/M_{i,t} \quad (2.3) \\ & + g_2 A_{i,t} Noise_{i,t} + g_3 A_{i,t} \psi_i + g_4 A_{i,t} Own_{i,t} + g_5 A_{i,t} Tenure_{i,t} \\ & + h_0 r_{i,t} + h_\tau r_{i,t-\tau} + \Gamma K + \varepsilon_{i,t} \end{aligned}$$

The slope coefficient $b_\tau$ captures the effect of more extreme past returns $||r_{i,t-\tau}||$ on the sensitivity of CEO pay to earnings. Hypothesis 2, which predicts that firms with more extreme past returns lower the sensitivity of CEO pay to earnings, implies that $b_\tau < 0$. Hypothesis 3 predicts that the weight on earnings is lower for extreme returns from the more recent past than for extreme returns from the more distant past, indicating that $b_1 < b_2 < b_3$.

### 2.4.1 CEO cash pay

Table G.5 shows the results from estimating regression (2.3) for CEO cash pay. The discussion focusses on columns (3) and (6), which include all three lags of past returns. The evidence supports Hypothesis 2 and shows that the weight on earnings declines as past returns become more extreme. The coefficient $b_\tau$ on earnings interacted with the ranked absolute value of past returns $A_{i,t}||r_{i,t-\tau}||$ is significantly negative for returns from $t-1$ and $t-2$. The effect of returns from $t-1$ on the weight on earnings is $b_1 = -0.593$ ($t$-statistic of $-6.00$). For returns in $t-2$, the impact is $b_2 = -0.413$ ($t$-statistic of $-4.03$). The effect of returns from $t-3$ is $b_3 = -0.051$ ($t$-statistic of $-0.55$). This evidence is consistent with the argument that larger past shocks increase estimation risk, leading to a lower weight on earnings.[7] Finally, the coefficient $c_\tau$ on past returns $||r_{i,t-\tau}||$ is significantly positive, indicating that CEO salary is larger when estimation risk is higher.

The economic significance of the results for the weight on earnings is explored using the estimated coefficient $b_1$ from column (3). For the most extreme returns in $t-1$ ($||r_{i,t-1}|| = 1$), the sensitivity of CEO cash pay to earnings is $1.265 - 0.593 \times 1 + 0.010 \cong 0.682$, where 0.010 is the sum of the coefficients in $g_1$ through $g_5$ on earnings $A_{i,t}$ interacted with the variables affecting the weight on earnings.[8] For every 10% increase in earnings, CEO cash pay rises by 6.8%, or $69,930 when applied to average CEO cash pay of $1,025,000 from Table G.2. For the least extreme returns in $t-1$ ($||r_{i,t-1}|| = 0$), the sensitivity of CEO cash pay to earnings is $1.265 - 0.593 \times 0 + 0.010 \cong 1.28$. For every 10% increase in earnings, CEO cash pay rises by about 12.8%, or $130,720. Overall, this analysis shows that the pay-performance sensitivity to earnings varies widely between the least extreme and the most extreme past returns. It is about 87% ($= \frac{\$130{,}720-\$69{,}930}{\$69{,}930}$) higher for the least extreme past returns than for the most extreme past returns.

Furthermore, Table G.5 provides some support for Hypothesis 3. Returns from $t-1$ lead to an economically larger decline in the sensitivity of CEO cash pay to

[7]The thesis also examines whether the pay-performance sensitivity to earnings is different when past returns are negative than when they are positive. The results are only significant at the 10% level, and suggest that the weight on earnings is marginally lower when past returns are negative than when they are positive. A possible explanation for this result is that GAAP allows more managerial judgement for the recognition of negative shocks than for the recognition of positive shocks. This increased managerial judgement for negative shocks may imply that the effect of negative shocks on earnings noise can be less precisely estimated than the impact of positive shocks.

[8]$0.010 \cong (-0.413)(0.50) + (-0.051)(0.50) + (-0.037)(0.71) + (-1.030)(0.49) + (0.328)(0.70) + (-0.027)(-5.25) + (0.205)(1.96)$, where 0.50, 0.50, 0.71, 0.49, 0.70, −5.25 and 1.96 are the average values for $||r_{i,t-2}||$, $||r_{i,t-3}||$, $B/M_{i,t}$, $Risk_{i,t}$, $\psi_i$, $Own_{i,t}$ and $Tenure_{i,t}$.

earnings than returns from $t-2$. The coefficient $b_1$ on earnings interacted with returns from $t-1$, $A_{i,t}||r_{i,t-1}||$, has a value of $-0.593$ and is about 44% smaller than the coefficient $b_2$ on earnings interacted with returns from $t-2$, $A_{i,t}||r_{i,t-2}||$, which equals $-0.413$. Statistically, the difference is significant only at the 16.9% level, which is outside the conventional confidence interval. The returns from both $t-1$ and $t-2$ lead to an economically and statistically lower weight on earnings than the returns from $t-3$. The reported $p$-values indicate that the difference between the coefficient $b_1$ on earnings interacted with returns from $t-1$ and the coefficient $b_3$ on earnings interacted with returns from $t-3$ is significant at the 1% level, while the difference between the coefficient $b_2$ on earnings interacted with returns from $t-2$ and $b_3$ is significant at the 5% level. Overall, these results provide some support for Hypothesis 3, and suggest that the CEO and the compensation committee learn over time about more extreme shocks, which lowers estimation risk.

Table G.5 shows that the control variables for the weight on earnings yield coefficients that have the predicted signs. Firms with riskier earnings, given by $Risk_{i,t}$, put less weight on earnings, consistent with Lambert and Larcker (1987). Section 2.6 further explores the difference between estimation risk and $Risk_{i,t}$. The sensitivity of CEO cash pay to earnings is found to increase with earnings persistence $\psi_i$, as in Baber et al. (1998). Also, the results indicate that longer CEO tenure leads to a larger sensitivity of CEO cash pay to earnings, consistent with Gibbons and Murphy (1992). CEOs with longer tenure are closer to retirement and have less implicit incentives from career concerns. Instead, they receive larger explicit incentives in the form of pay-for-performance.

### 2.4.2 CEO bonus pay

Table G.6 shows that for CEO bonus pay, the main tenor of the findings is unchanged compared to the results for CEO cash pay in Table G.5. The evidence continues to support Hypothesis 2. Column (3) indicates that the coefficients $b_\tau$ on earnings interacted with past returns $A_{i,t}||r_{i,t-\tau}||$ is significantly negative for returns from $t-1$ and $t-2$. The effect of returns from $t-1$ on the weight on earnings is $b_1 = -3.570$ ($t$-statistic of $-6.44$). For returns in $t-2$, the impact is $b_2 = -1.200$ ($t$-statistic of $-2.55$). Finally, the effect of returns from $t-3$ is given by $b_3 = -0.663$ ($t$-statistic of $-1.41$). In terms of economic significance, the results for CEO bonus pay are similar to the findings for CEO cash pay. When returns in $t-1$ are most extreme ($||r_{i,t-1}|| = 1$), the pay-performance sensitivity is 4.58.[9] For every 10% increase in earnings, CEO bonus pay increases by 45.8%, which translates into a rise of \$242,240 when applied to average CEO bonus pay of \$529,000 in Table G.2. When returns from $t-1$ are least extreme ($||r_{i,t-1}|| = 0$), the weight on earnings is 8.15.[10] For every 10% increase in earnings, CEO bonus pay rises by 81.5%, or \$431,090. The sensitivity of CEO bonus pay to earnings is thus about 78% ($= \frac{\$431,090-\$242,240}{\$242,240}$) higher when returns in $t-1$ are least extreme than when they are most extreme.

The evidence in Table G.6 also supports Hypothesis 3. Column (3) indicates that the coefficient $b_1$ on earnings interacted with returns from $t-1$, $A_{i,t}||r_{i,t-1}||$, has a value of $-3.570$ and is about three times lower than the coefficient $b_2$ on earnings interacted with returns from $t-2$, which has a value of $-1.200$. Furthermore,

---

[9] $4.58 \cong 7.99 - 3.57 \times 1 - 1.2 \times 0.5 - 0.663 \times 0.5 + 0.25$, where 0.25 is the sum of the coefficients in $g_1$ through $g_5$ on earnings $A_{i,t}$ interacted with the control variables for the weight on earnings, with the control variables taken at their mean values.

[10] $8.15 \cong 7.99 - 3.57 \times 0 - 1.2 \times 0.5 - 0.663 \times 0.5 + 0.25$, where 0.25 is the sum of the coefficients in $g_1$ through $g_5$ on earnings $A_{i,t}$ interacted with the control variables for the weight on earnings, with the control variables taken at their mean values.

the reported $p$-value indicates that the difference between $b_1$ and $b_2$ is statistically significant at the 1% level. Similarly, $b_1$ is economically and statistically lower than the coefficient $b_3$ on returns from $t-3$, which has a value of $-0.663$. Recall from the analysis of CEO cash pay in Table G.5 that returns from $t-1$ do not have an impact on the weight on earnings that is statistically different from the effect of returns from $t-2$. The evidence in Table G.6 suggests this lack of a differential impact is not driven by CEO bonus pay, which is the component of CEO cash pay that is most sensitive to earnings.

## 2.5 Test of Hypothesis 4

This section tests Hypothesis 4, which predicts that the relative weight on subjective and non-financial performance measures increases after large economic shocks, when estimation risk is high. Firms discuss the relative importance of various performance measures in their proxy statements. For instance, National Computer Systems Inc. writes in its 1999 proxy statement that "Threshold, target and maximum goals for Company and business unit performance are set at the beginning of the year with 70% of individual bonus amounts based on achieving corporate or business unit revenue and earnings goals and 30% based on achievement of predefined personal goals" (National Computer Systems Inc., 1999). Hence, evidence from proxy statements is used to test Hypothesis 4. Because the data on subjective and non-financial performance measures has to be handcollected, this thesis restricts the detailed analysis of these performance measures to a subsample of the firms used in the main analysis, as described next.

### 2.5.1 Experimental and control firms

A set of experimental and control firms is defined to test Hypothesis 4. Experimental firms are those sample firms experiencing the most extreme economic shocks (and facing the highest estimation risk) in $t-1$. They belong to the two percentiles of sample firms with the most extreme negative and positive returns in $t-1$. The focus on firms exposed to the largest shocks and the highest estimation risk increases the likelihood of finding information in proxy statements about how firms modify the use of subjective and non-financial performance measures following changes in estimation risk. However, since experimental firms represent extreme cases, the extent to which the evidence from this analysis can be generalized to the population of all firms exposed to lesser modifications in estimation risk is limited.

Control firms are those sample firms experiencing the smallest economic shocks (and facing the lowest estimation risk) in $t-1$. They belong to the two percentiles of sample firms with the least negative and positive returns in $t-1$. Each experimental firm is matched with a control firm in the same fiscal year and the same 2-digit SIC code and closest in size, in terms of the market value of common equity at the end of $t-2$. This matching procedure aims to disentangle the effect of estimation risk from possible size and industry driven differences. A pair of experimental and matched control firms is retained only if proxy statements for both firms are available in the year of the economic shock, $t-1$, and the following year, $t$. The final subsample consists of 196 experimental firms and 196 matched control firms between 1993 and 2003. For each experimental and each control firm, proxy statements are examined for information about subjective and non-financial performance measures in $t-1$ and $t$.

Table G.7 presents the time and industry profile for the 196 experimental firms. Since control firms are matched to experimental firms by fiscal year and industry, their time and industry profile mirrors that of experimental firms. Panel A shows that firms are clustered at the end of the sample period, with about one quarter of experimental firms belonging to the 1993-1997 period, and three quarters to the 1998-2002 period. Between 1998 and 2000 (the "internet boom"), the NASDAQ rose by more than 300% before starting to fall in early 2000. The U.S. economy went into a recession between 2000 and 2001. It is not surprising that experimental firms, all of which experience extreme shocks, are clustered in a period of a boom followed by a bust. Panel B of Table G.7 shows that the firms are spread across 29 2-digit SIC codes, with 28.4% of the firms in SIC industry 36 (Electronics), 20.8% in SIC industry 73 (Business Services), 13.7% in SIC industry 28 (Chemicals) and 9.7% in SIC industry 35 (Industrial & Commercial Machinery).

Table G.8 reports descriptive statistics on CEO pay, CEO characteristics and firm characteristics in $t$, the year after the economic shock. Experimental firms have lower book-to-market ratios in $t$ and higher return volatility over the five years prior to $t$ than control firms. Recall that experimental firms are defined as experiencing extreme shocks in $t-1$, which are identified by the size of their returns. Control firms on the other hand are defined as not experiencing shocks in $t-1$. Since return volatility is measured over the five years prior to $t$, it is not surprising that experimental firms have higher return volatility than control firms.

Return volatility can affect the use of subjective and non-financial performance measures in two ways. First, higher return volatility implies that stock returns include more risk from market movements, and/or more idiosyncratic risk. Hence the relative weight on returns falls, and the relative use of subjective and non-financial performance measures rises. Second, return volatility likely correlates with earnings volatility, because of the positive relation between earnings and returns (Collins et al., 1994). Hence, higher return volatility implies that earnings include more risk from market movements, and/or more idiosyncratic risk. Furthermore, the parameters of the earnings noise distribution likely are more difficult to estimate, thus increasing estimation risk. Therefore, in this second scenario, the relative weight on earnings falls as return volatility increases, and the relative use of subjective and non-financial performance measures increases. Overall, this discussion suggests an increase in return volatility leads to a higher weight on subjective and non-financial performance measures, similar to the predicted effect of a rise in estimation risk. Thus, the positive correlation between the estimation risk proxy and return volatility implies that the results in this section may reflect the effect of the higher return volatility on the use of subjective and non-financial performance measures, rather than the impact of higher estimation risk.

CEO pay structures reflect the differing environments in which experimental and control firms operate. Experimental firms pay out a higher proportion of equity-based pay, defined as the sum of restricted stock grants and stock options. On average, about 50% of total pay is equity-based for experimental firms, compared to 42% for control firms. Furthermore, CEOs own a larger percentage of the outstanding shares in experimental firms (about 5.5%) than in control firms (about 3.3%). These results are consistent with the argument that firms operating in more uncertain environments have higher monitoring costs. Monitoring costs can be lowered by higher concentrations of ownership (Demsetz and Lehn, 1985) and by more equity-based pay (Smith and Watts, 1992). Table G.8 also shows that experimental firms pay out lower levels of bonus pay than control firms. This finding may obtain because firms provide less earnings-based pay to CEOs who already have high equity-based incentives.

### 2.5.2 Subjective and non-financial performance measures

Table G.9 presents the criteria used to identify subjective performance measures (in Panel A) and objective non-financial performance measures (in Panel B). Objective non-financial performance measures are based not on financial measures such as earnings or cash flows, but on measures such as customer service and product quality. For instance, the experimental firm Astec Industries reports in its 1998 proxy statement that the performance measures used in its executive bonus pay are "returns on capital employed, cash flow on capital employed, growth and safety" (Astec Industries, 1999). The performance measure "safety" is considered to be an objective non-financial performance measure.

A performance measure is subjective if firms evaluate the CEO with discretion or subjectivity. Firms can use subjectivity in evaluating the CEO in three major ways (Bushman et al., 1996; Murphy and Oyer, 2003; Ittner et al., 2003; Gibbs et al., 2004). First, firms can exclusively rely on subjective judgement to determine CEO bonus. Second, firms can subjectively adjust objective financial and objective non-financial performance measures ex post or change their weight ex post. Third, firms can subjectively adjust bonus awards based on performance measures other than those specified ex ante in the bonus contract. Based on these criteria, the present thesis identifies subjectivity in CEO bonus pay in three ways, as outlined in Panel A in Table G.9. First, firms are considered to use subjectivity in evaluating the CEO if they explicitly mention the word "subjective" and/or "discretion" (or any variation of these two words) in the description of the CEO's bonus plan. Proxy statements are oftentimes explicit about compensation committees using discretion. For example, the experimental firm Parametric Technology Corp. reports in its 2003 proxy statement that "The incentive plans for fiscal 2003 set forth two performance factors for each participating officer (including the Chief Executive Officer): revenue and operating margin. Target levels were established for each performance factor and a gross target bonus corresponding to each of the target levels was set. Because neither the revenue nor operating margin targets were met for fiscal 2003, funding for the incentive bonuses was at the Committee's discretion." (Parametric Technology Corp, 2003).

Individual performance measures are also considered subjective, following Bushman et al. (1996). For instance, the experimental firm Royal Appliance writes in its 1994 proxy statement that "The Committee based the 1994 compensation of Mr. Balch [its CEO] on the policies and procedures described above [in the section about the company's bonus plan] [...]". Royal Appliance then indicates indirectly that besides its formal bonus plan, it uses discretion in evaluating its CEO's performance, by writing that "In addition, the Committee took into account its assessment of Mr. Balch's individual performance and his ability to expand and develop new markets and products" (Royal Appliance MFG Co, 2003). Finally, if firms describe performance measures used to determine CEO bonus pay that have not been explicitly specified ex ante in the bonus contract (such as Royal Appliance does), then those performance measures are also considered subjective.

Only very few firms provide direct information about the relative weights attributed to their subjective and non-financial performance measures. 11 experimental firms and 13 control firms mention the weights attributed to these performance measures in $t-1$ and in $t$. Of the 11 experimental firms, two increase the weight on subjective and non-financial performance measures from $t-1$ to $t$, while the other nine do not alter the weight. Of the 13 control firms, two lower and one increases the weight on these performance measures between $t-1$ and $t$, while ten do not change the weight. Since so few firms provide direct weighting information, no meaningful inferences can be drawn from this evidence. Hence, other aspects of the information provided in proxy statements about subjective and non-financial performance measures have to be analyzed in other to test Hypothesis 4.

### 2.5.3 The frequency of subjective and non-financial performance measures

First, this thesis examines the frequency with which all experimental and control firms report using specific subjective and non-financial performance measures in $t-1$ and $t$. Table G.10 displays the nature of the various subjective and objective non-financial performance measures as well as their frequencies. Experimental firms report subjective performance measures 518 times in $t$, up from 427 times in $t-1$. Control firms, on the other hand, report subjective performance 328 times in $t$, down from 384 times in $t-1$. The difference between experimental and control firms is significant at the 1% level ($\chi^2 = 12.43$).

The various subjective performance measures are sorted into categories that stress the commonality between them. The first category in Table G.10, "Financial and individual performance measures," refers to instances where firms base their subjective performance measures on some measure of financial performance, or where they report using individual performance evaluation. Experimental firms rely on subjective financial and individual performance measures 206 times in $t$, up from 177 times in $t-1$. Control firms, on the other hand, employ less of these performance measures, using them 158 times in $t$, down from 185 times in $t-1$.

The difference between experimental and control firms is significant at the 5% level ($\chi^2 = 4.32$). The increased use of subjective financial and individual performance measures between $t-1$ and $t$ is driven by higher subjective emphasis on financial performance measures ($\chi^2 = 5.87$), such as "Sales" ($\chi^2 = 8.20$) and "Cost control" ($\chi^2 = 5.81$).

Table G.10 shows that experimental firms also increase the use of subjective non-financial performance measures to a larger degree than control firms. Specifically, experimental firms use subjective non-financial performance measures 312 times in $t$ up from 250 times in $t-1$. Control firms on the other hand use subjective non-financial performance measures 170 times in $t$, down from 199 times in $t-1$. The difference between experimental and control firms is significant at the 1% level ($\chi^2 = 7.96$). Finally, note that non-financial performance measures are not used objectively very often. For instance, in $t$, experimental firms report using non-financial performance measures in an objective manner 76 times, whereas they report using them in a subjective fashion 312 times. More importantly, the difference between experimental and control firms is not significant for objective non-financial performance measures ($\chi^2 = 0.06$). For the remainder of the analysis, this thesis focuses only on the major categories displayed in Table G.10, that is subjective financial and individual performance measures, subjective non-financial performance measures, and objective non-financial performance measures. Subjective financial and individual performance measures are grouped together to distinguish them from subjective non-financial performance measures. The overall results do not depend on the grouping.

### 2.5.4 The number of subjective and non-financial performance measures

Table G.11 displays the average number of subjective and objective non-financial performance measures used by each experimental and control firm in $t-1$ and $t$. The evidence suggests that experimental firms are on average more likely than control firms to increase the number of reported subjective performance measures between $t-1$ and $t$. Consider Panel A.1, which focuses on subjective financial and individual performance measures. On average, experimental firms use 1.06 such performance measures in $t$, up from 0.92 in $t-1$. On the other hand, control firms use 0.81 such measures in $t$, down from 0.94 in $t-1$. The change in the number of performance measures between $t-1$ and $t$ is significant at the 1% level for both experimental and control firms, as indicated by the $p$-values for the $t$-statistic and the Signed Rank test.

Next, the difference between experimental and control firms is assessed, using matched pair analysis. This analysis tests whether, on average, the change in the number of performance measures between $t-1$ and $t$ is different for experimental firms than for their matched control firms. Column (3) in Panel A.1 shows that experimental firms are significantly more likely than control firms to significantly increase the average number of subjective financial and individual performance measures between $t-1$ and $t$, using both the Student $t$-test and the Signed Rank test. The same conclusion applies to subjective non-financial performance measures, according to the Signed Rank test.

Table G.12 extends the evidence in Table G.11 by providing further non-parametric analysis of how firms change the number of subjective and non-financial performance measures used in $t-1$ and in $t$. It displays the number and percentage of firms that increase, decrease or keep constant the number of subjective and non-financial performance measures between $t-1$ and $t$. The evidence in Table G.12 indicates that experimental firms are more likely than control firms to increase the number subjective performance measures between $t-1$ and $t$. For instance, Panel A.1 shows that 26 (13.3%) experimental firms raise the number of subjective financial and individual performance measures between $t-1$ and $t$, while only 9 (4.6%) control firms do so. Furthermore, experimental firms are less likely than control firms to decrease the number of subjective financial and individual performance measures between $t-1$ and $t$. 19 (9.7%) control firms lower the number of these performance measures, while only 5 (2.6%) experimental firms do so. The difference between experimental and control firms is statistically significant at the 1% level ($\chi^2 = 16.45$).

### 2.5.5 The number of firms using subjective and non-financial performance measures

The analysis in Section 2.5.3 and Section 2.5.4 involves the number of performance measures described in the proxy statements of experimental and control firms. Some firms do not detail the specific number of performance measures used, but merely report whether or not they rely on subjective and/or objective non-financial performance measures. In order to take into account such firms (in addition to firms that identify the number of performance measures), this section analyzes all firms that report using subjective and objective non-financial performance measures. Table G.13 shows the number of firms that use subjective or non-financial performance measures in $t-1$ and $t$. The evidence suggests that experimental firms are significantly more likely than control firms to use subjective performance measure in the year after the economic shock, $t$, but not in the year of the shock, $t-1$.

For instance, Panel A.1 of Table G.13 shows that 117 (59.7%) experimental firms report using subjective financial and individual performance measures in $t$, up from 102 (52.0%) in $t-1$. Control firms, on the other hand, lower their reported use of subjective financial and individual performance measures between $t-1$ and $t$. In $t$, 84 (42.9%) control firms use such performance measures, down from 90 (45.9%) in $t-1$. Column (5) indicates that the difference between experimental and control firms is significant at the 1% level ($\chi^2 = 11.12$) in $t$, but not in $t-1$ ($\chi^2 = 1.47$). Table G.14 displays the number of firms that report increasing, decreasing or keeping constant the use of subjective and non-financial performance measures between $t-1$ and $t$. A firm increases [decreases] the use of subjective or objective non-financial performance measures if it does not [does] mention them in their proxy statement in $t-1$, but does [does not] mention them in their proxy statement in $t$. Table G.14 confirms the results from Table G.13. For instance, Panel A.1 in Table G.14 indicates that experimental firms are significantly more likely than control firms to increase the reported use of subjective financial and individual performance measures between $t-1$ and $t$.

The results are similar for subjective performance measures and for subjective non-financial performance measures, as shown in Panel A and Panel A.2 in Table G.13 and Table G.14. Finally, Panel B in both these tables indicates that firms do not appear to use objective non-financial performance measures very frequently, and that they do not significantly change their use after large economic shocks.

### 2.5.6 Discussion

The three previous sections provide two sets of results. First, following large economic shocks when estimation risk is high, firms increasingly report that they use subjective performance measures. Second, firms indicate that they rely on a higher number of such performance measures after large shocks. In order to conclude from this evidence that firms raise the relative weights on subjective performance measures, it is necessary to assume that a firm is more likely to report performance measures in its proxy statements when it in fact attributes a higher weight to them.

This assumption is consistent with the concept of materiality, which applies to proxy statement disclosures. The concept of materiality in the context of proxy statements has been defined by the U.S. Supreme Court as being met if there is "a substantial likelihood that the disclosure of the omitted fact would have been viewed by the reasonable investor as having significantly altered the 'total mix' of information made available" (TSC Industries, Inc. v. Northway, Inc., 426 U.S. 438, 96 S.Ct.2126, 48 L.Ed. 2d 757 (1976)). SEC Rule 14a-9 provides that it is unlawful to make a false or misleading statement of material fact in a proxy statement or to omit stating a material fact that is necessary to prevent any assertion in the proxy statement from being false or misleading. This rule suggests that the omission in proxy statements of performance measures used in CEO cash pay can have consequences for firms. For instance, in Shaev versus Datascope Corp. (3d Cir. 2003), the Third U.S. Circuit Court of Appeals found a potential violation of SEC Rule 14a-9 when a company did not fully disclose the material terms of the CEO's incentive pay program, including the CEO's performance goals. The Supreme Court has also underlined that the omission of relevant information from proxy statements violates the concept of materiality.

This discussion implies that performance measures are more likely to be reported in proxy statements when firms attribute more weight to these performance measures. The analysis in this section thus suggests that firms increasingly rely on subjective performance measures following large economic shocks, when estimation risk is high, consistent with Hypothesis 4. This conclusion is subject to the caveat, discussed earlier, that the results in this section may reflect the effect of higher return volatility, rather than the impact of higher estimation risk.

## 2.6 Relation to prior literature and alternative explanations

Contracting theory shows that the weight on a performance measure declines with its risk (Lambert and Larcker, 1987; Banker and Datar, 1989; Lambert, 2001). The executive compensation literature generally supports this prediction. One branch of the literature focusses on the historical time-series variance of performance measures such as earnings (Lambert and Larcker, 1987; Core et al., 2003) or returns (Aggarwal and Samwick, 1999; Jin, 2002). The evidence indicates that the weight on these performance measures declines with their historical time-series variance. Another branch of the literature further decomposes the historical time-series variance into its firm-specific and systematic components (Lambert and Larcker, 1987; Sloan, 1993; Jin, 2002). The evidence shows that the weight on performance measures declines as systematic risk increases (Lambert and Larcker, 1987; Sloan, 1993) or as firm-specific risk rises (Jin, 2002).

The approach in the extant literature to focus on the historical time-series variance of a performance measure raises two issues. First, the historical time-series variance need not be a good proxy for the future time-series variance, for instance if the firm is undergoing a reorganization. Second, the historical time-series variance may not capture all sources of risk. The current thesis argues that a potentially important source of risk, estimation risk, has been omitted in the literature. Estimation risk is a source of risk that is incremental to conventional risk sources, which arise because of known variation in earnings noise around a known mean. To illustrate how estimation risk is different, consider market movements in earnings. More volatile market movements in earnings lead to a lower weight on earnings (Sloan, 1993). This occurs because market movements in earnings are noise, whose known variations around a known mean introduce risk into earnings-based CEO cash pay. In the current thesis, market movements in earnings give rise to an additional source of risk, estimation risk, because mean market movements in earnings are not known. This estimation risk is higher when the CEO and the compensation committee cannot provide a very precise estimate of the mean market movements in earnings.

This thesis controls for traditional sources of risk using various risk proxies, and its results hold, as shown in Table G.15. Panel A uses the dispersion of analysts' forecasts, $Disp_{i,t-1}$, as the estimation risk proxy, while Panel B relies on the absolute magnitude of past returns $||r_{i,t-\tau}||$. In both panels, column (1) shows the results when no proxy for risk other than estimation risk is included, whereas columns (2) to (4) display the findings after including three different proxies for such risk. Column (2) focusses on the risk measure developed in Lambert and Larcker (1987), further described in Appendix D, and shows that the main findings of this thesis hold.

Since the absolute weight on earnings depends on the risk in earnings and not of the ratio of the risk in earnings to the risk in returns, risk in earnings is redefined as the ranked standard deviation of earnings over the five years prior to the sample year (Lambert and Larcker, 1987; Banker and Datar, 1989; Lambert, 1993). Column (4) of Table G.15 shows that the main results of this thesis hold when this measure of risk is included. Finally, the analysis controls for the Sloan (1993) measure of risk, defined as the extent to which earnings fluctuations, compared to return fluctuations, result from market movements. This variable is further detailed in Appendix D. As shown in column (3) of Table G.15, the principal findings of this thesis are unaffected by the inclusion of this latter risk proxy.

The evidence in Table G.15 indicates that the sensitivity of CEO cash pay to earnings varies with the proxies for estimation risk *after* controlling for other sources of earnings risk already examined in the literature. This finding suggests that the estimation risk proxies used in this thesis capture an additional economic determinant of the weight on earnings, namely estimation risk. This conclusion assumes that the empirical controls for sources of risk other than estimation risk fully capture risk in next year's earnings that does not result from estimation risk. This is not necessarily the case, since the empirical proxies for sources of risk other than estimation risk follow the literature and are backward-looking. Such backward-looking measures are problematic if sources of risk not stemming from estimation risk are not constant over time. In that case, the backward-looking risk controls may not capture all sources of risk in next year's earnings other than estimation risk. Hence it cannot be concluded that the two forward-looking proxies for estimation risk capture only estimation risk. Rather, these two forward-looking proxies for estimation risk may reflect other sources of risk in next year's earnings in addition to estimation risk. Thus the two estimation risk proxies used in this thesis may be better empirical measures of such sources of risk than the constructs previously used in the literature.

# Chapter 3

# Further analysis of CEO cash pay characteristics

The main regression model used in the empirical analysis of this thesis is consistent with common practice in the executive compensation literature whereby the level of CEO cash pay is regressed against the level of earnings (see for instance Core et al. (1999)). However, such a regression model does not account for a performance standard, nor does it consider the bonus bounds inherent in CEO bonus pay contracts. This chapter analyzes the effect of taking into account these two characteristics. Furthermore, this chapter also examines the sensitivity of the main results from this thesis to various research settings.

## 3.1 The impact of the performance standard

The discussion in Section 2.2 argues that firms use performance standards that are adjusted for prior-year economic shocks. For example, when past shocks are more positive, firms likely increase performance standards in order not to pay rents to their CEOs. The performance measure that results from this adjustment process is given by $[A_{i,t} - \overline{A_{i,t}}]$, where $A_{i,t}$ is earnings, $\overline{A_{i,t}} = \overline{A'_{i,t}} + f(r_{i,t-\tau})$ is the performance standard for earnings. $\overline{A'_{i,t}}$ is the performance standard before the adjustment for shocks from $t - \tau$. Stock returns $r_{i,t-\tau}$ are used to capture shocks from $t - \tau$, since returns are timely in reflecting information. This study takes into account the adjustment for past shocks (given by $f(r_{i,t-\tau})$), by including prior-year stock returns $r_{i,t-\tau}$ going back to $t - 3$ in all of its regressions.

However, this study has not yet controlled for the performance standard before the effect of past shocks, $\overline{A'_{i,t}}$, which is not directly observable. The main regression model in equation (2.1) is thus subject to an omitted variables problem. Unless the performance standard is not correlated with the variables included in equation (2.1), this omitted variables problem biases the coefficients on the included variables. The direction of this bias cannot be predicted (Greene, 1997). Hence, it is not clear whether the omitted variables problem causes the coefficient on earnings to be biased upwards or downwards.

Murphy (2000) investigates the bonus contract details of 177 large industrial U.S. companies in 1996 and 1997, and documents that the most commonly used performance standard are budgets, and prior-year earnings. Because budget information is not available, prior-year earnings $A_{i,t-1}$ are used to capture $\overline{A'_{i,t}}$, implying that $\overline{A'_{i,t}} = A_{i,t-1}$. The study recomputes its tests of Hypothesis 1 from Table G.4 and of Hypothesis 2 and Hypothesis 3 from Table G.5 by including prior-year earnings $A_{i,t-1}$ as an independent variable. The following regression is thus estimated for firm $i$ in fiscal year $t$.

$$\begin{aligned} C_{i,t} &= a_0 + b_0 A_{i,t} + \mathbf{b_1 A_{i,t} EstimationRisk} + b'_0 A_{i,t-1} \\ &\quad + \mathbf{b'_1 A_{i,t-1} EstimationRisk} + c_\tau EstimationRisk \\ &\quad + \Omega A_{i,t} CV + \Omega' A_{i,t-1} CV + h_0 r_{i,t} + h_\tau r_{i,t-\tau} + \Gamma K + \varepsilon_{i,t} \end{aligned} \tag{3.1}$$

The variable $EstimationRisk$ is one of the two proxies for estimation risk, $Disp_{i,t-1}$

or $||r_{i,t-\tau}||$. The coefficient $b_1$ captures the effect of estimation risk on the pay-performance sensitivity to earnings and is expected to be negative. The coefficient $b'_0$ on $A_{i,t-1}$ is also expected to be negative if prior-year earnings $A_{i,t-1}$ are used as a performance standard, as suggested by Murphy (2000). Finally, the coefficient $b'_1$ on $A_{i,t-1}$ interacted with the estimation risk proxy is expected to be of the opposite sign of $b_1$ ($b'_1 = -b_1$), that is positive.

Table G.16 shows the results in Panel A (B) when the estimation risk proxy is $Disp_{i,t-1}$ ($||r_{i,t-\tau}||$). In both panels, the coefficient $b_1$ on earnings interacted with the estimation risk proxy has the predicted negative sign. For instance, in Panel A, the coefficient on earnings interacted with the dispersion of analysts' forecasts $A_{i,t}Disp_{i,t-1}$ is $b_1 = -0.527$ ($t$-statistic of $-3.58$). Column (2) shows that the coefficient on prior-year earnings interacted with the estimation risk proxy has the predicted positive sign in the two panels. For example, the coefficient on prior-year earnings interacted with the dispersion of analysts' forecasts $A_{i,t-1}Disp_{i,t-1}$ is significantly positive at 12.53 ($t$-statistic of 3.36). Finally, in both panels, the coefficient $b'_0$ on prior-year earnings $A_{i,t-1}$ is significantly negative. For instance, in Panel A, $b'_0 = -19.10$ ($t$-statistic of $-1.70$). The findings in column (2) thus support the notion that prior-year earnings are used as a performance standard.[1]

Overall, Table G.16 suggests that the omission of the performance standard does not substantially affect the results of this thesis. If variation in performance standards across firms and time reflects observable and unobservable firm and CEO

[1]This study has argued before that the performance standards are adjusted for past shocks. The theoretical specification for earnings minus the performance standard is then $[A_{i,t} - A_{i,t-1} - f(r_{i,t-\tau})]$, suggesting that $r_{i,t-\tau}$ has to be interacted with the estimation risk proxy. Untabulated results show that when this additional interactive term is considered, the main findings from this study are qualitatively the same (using up to three years of past returns).

characteristics that the thesis has already captured through its control variables and its fixed effects estimation technique, this finding is not surprising. Evidence in Indjejikian and Nanda (2002) suggests that performance standards vary with risk in earnings, and growth options. This thesis includes both of these variables in its analysis without the performance standard.[2]

## 3.2 The impact of non-linearities

This section examines the effect of lower and upper bonus bounds on its main results. While all bonus plans have a lower bound below which no bonus is earned, not all bonus plans have an upper bound. For instance, Healy (1985) and Gaver et al. (1995) document that only about 30% of their sample firms specify an upper bound in their bonus contracts. However, the evidence in Murphy (2000) suggests that the use of upper bonus bounds is more widespread. He documents that about 80% of his sample firm-years cap their bonuses.[3] Given this conflicting evidence on the extent to which upper bonus bounds are used, this thesis first re-examines its main results taking into account only the lower bonus bound. In a second step, the impact of an upper bonus bound is investigated.

### 3.2.1 The effect of lower bonus bounds

The analysis of the lower bonus bound includes only firm-years where the CEO earns a bonus and thus selects the sample on the dependent variable, which is CEO cash

---

[2]The study also uses average analysts' forecasts made in $t-1$ for earnings in $t$ as a proxy for the performance standard. The main findings of the study hold. Furthermore, the results do not suggest that average analysts' forecasts are widely used as a performance standard, consistent with evidence in Murphy (2000).

[3]Healy (1985) uses 1,527 firm-years from Fortune 250 between 1930 and 1980, Gaver et al. (1995) use 837 firm-years from the Q-file between 1980 and 1990, and Murphy (2000) uses 177 firms from Towers Perrin in 1996 and 1997.

pay and includes CEO bonus pay. Least squares estimation is inconsistent when there is sample selection (Greene, 1997). The Heckman estimation method, which relies on a two-stage model, adjusts for such sample selection. In the first stage, the probability of the CEO being awarded a bonus is predicted. In the second stage, the main empirical model in equation (2.1) is re-estimated for firm-years where the CEO is awarded a bonus.

**First stage: predicting CEO bonus awards**

The following model for firm $i$ in $t$ is used to predict CEO bonus awards.

$$\begin{aligned} Bonus_{i,t} \;=\; & \delta_0 + \delta_1 A_{i,t} + \delta_2 Threshold_{A_{i,t}} + \delta_3 DA_{i,t} + \delta_4 r_{i,t} + \delta_5 r_{i,t-1} \\ & + \delta_6 r_{i,t-2} + \delta_7 r_{i,t-3} + \delta_8 BonInd_{i,t} + \delta_9 Cash_{i,t} + \delta_{10} Debt_{i,t} \\ & + \delta_{11} B/M_{i,t} + \delta_{12} Vol_{i,t} + \delta_{13} Size_{i,t} + \delta_{14} Own_{i,t} + \delta_{15} Chair_{i,t} \\ & + \delta_{16} Tenure_{i,t} + \delta_{17} Meet_{i,t} + \delta_{18} Interlock_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{3.2}$$

The variable $Bonus_{i,t}$ equals 1 if the CEO is awarded a bonus in $t$, and 0 otherwise. Equation (3.2) is estimated with a probit model, which is the appropriate method in the context of the Heckman two-stage model. The explanatory variables in equation (3.2) are discussed below. Appendix D further details the definition of these variables. Fiscal year dummies and industry dummies, defined by two-digit SIC code, are included to control for fiscal year and industry effects (not shown in equation (3.2)).

- **Earnings** $A_{i,t}$. Most bonus plans use earnings as a performance measure (Murphy, 1999). Higher earnings raise the likelihood that the lower bonus bound is exceeded and that the CEO earns a bonus. Hence $\delta_1$ is expected to be positive.

- **Prior-year earnings threshold** $Threshold_{A_{i,t}}$. This variable equals 1 if earnings $A_{i,t}$ are larger than 80% of prior-year earnings $A_{i,t-1}$, and 0 otherwise. The majority of bonus plans are "80/120" plans, which allocate no bonus unless performance exceeds 80% of the performance standard, and cap bonuses at 120% of the performance standard (Murphy, 1999). Since many performance standards are based on prior-year performance, prior-year earnings are used to capture the lower bonus bound of 80% of the performance standard.[4] $\delta_2$ is predicted to be positive.

- **Contemporaneous earnings threshold** $DA_{i,t}$. This variable equals 1 if earnings $A_{i,t}$ are strictly negative, and 0 otherwise. CEOs are more likely to earn a bonus when earnings are positive. About 48% of the sample firms with negative earnings do not allocate a bonus to their CEO, which is the case for only about 15% of the firms with positive earnings. Although Murphy (1999) does not document that firms consider the zero earnings threshold relevant for CEO bonus awards, Murphy and Oyer (2003) find that compensation committees often exercise discretion ex post when determining CEO bonus pay. Furthermore, individuals frequently use zero as a reference point (Degeorge et al., 1999). $\delta_3$ is thus expected to be negative.

- **Contemporaneous market-adjusted returns** $r_{i,t}$. Some firms explicitly include returns in their bonus contracts (Murphy, 2000). Furthermore, firms consider non-accounting performance measures, such as customer satisfaction (Murphy, 1999; Ittner et al., 1997), and individual performances measures

[4]Leone and Rock (2002) document that budgets ratchet and that a CEO who makes the budget in the contemporaneous year will face a higher budget next year. To take into account ratcheting, the definition of $Threshold_{A_{i,t}}$ is modified to be 1 when earnings $A_{i,t}$ are larger than 80% of prior-year earnings $A_{i,t-1} + 0.1$, and 0 otherwise. The results are qualitatively unchanged.

(Bushman et al., 1996). To the extent that information about non-accounting and individual performance measures is reflected in stock prices, bonus awards are expected to relate positively to returns. Hence $\delta_4$ is predicted to be positive.

- **Past returns** $r_{i,t-\tau}$. Part of the information reflected in non-accounting and individual performance measures is anticipated in past returns. Furthermore, firms consider past returns when setting contemporaneous CEO cash pay (Joskow and Rose, 1994). Hence, bonus awards likely relate positively to $r_{i,t-\tau}$. Thus $\delta_5$, $\delta_6$, and $\delta_7$ are expected to be positive.

- **Industry bonus** $BonInd_{i,t}$. This variable measures the percentage of firms in company $i$'s industry that award CEO bonus pay in $t$. Industries are defined by two-digit SIC code. Firms set cash pay, including bonus pay, using information on pay practices of peer firms that are close in size and industry (Bizjak et al., 2003). Thus, firm $i$ is more likely to allocate a bonus to its CEO as $BonInd_{i,t}$ increases, and $\delta_8$ is predicted to be positive.

- **Cash constraint** $Cash_{i,t}$. This variable is the sum of common and preferred dividends (COMPUSTAT #19 and #21) plus cash flows used in investing activities (COMPUSTAT #311) minus cash flows from operating activities (COMPUSTAT #308) scaled by prior-year total assets, following Core and Guay (1999). Firms with less cash (and higher values of $Cash_{i,t}$) are less likely to award a bonus to their CEO (Zhou and Swan, 2003). Thus $\delta_9$ is expected to be negative.

- **Debt** $Debt_{i,t}$. This variable is the sum of long-term debt (COMPUSTAT #9) and debt in current liabilities (COMPUSTAT #34) divided by total contemporaneous assets. Firms with more debt are less likely to give CEO bonus awards (Zhou and Swan, 2003), implying that $\delta_{10}$ should be negative.

- **Growth options** $B/M_{i,t}$. This variable is the natural logarithm of the book value of the firm's assets in $t-1$ divided by the market value of the firm in $t-1$. Firms with more growth options are more likely to have incentive plans (Smith and Watts, 1992), including earnings-based bonus plans, and thus to allocate a bonus to their CEO. At the same time, because earnings are less informative about CEO effort in the presence of substantial growth options, firms with high growth options may be less likely to have earnings-based bonus plans. No prediction is therefore made for $\delta_{11}$.

- **Firm risk** $Vol_{i,t}$. This variable is the standard deviation of monthly stock returns over the 60 months prior to the sample year. CEOs of riskier firms have been found to be more likely to earn a bonus (Zhou and Swan, 2003), implying that $\delta_{12}$ should be positive.

- **Firm size** $Size_{i,t}$. This variable is the natural logarithm of sales from $t-1$. Firm size is positively related to CEO cash pay (Murphy, 1999). Zhou and Swan (2003) argue that performance thresholds are lower in larger firms, because such firms likely have smaller expected returns (due, for instance, to low stock illiquidity). Therefore, bonus awards likely are positively related to firm size, and $\delta_{13}$ is expected to be positive.

- **CEO stock ownership** $Own_{i,t}$. This variable is the natural logarithm of the percentage of company stock owned by the CEO of firm $i$ in year $t$. CEOs who own a higher percentage of the firm already have large performance-based incentives (Sloan, 1993). Therefore, they are less likely to receive other forms of incentive pay, including bonus pay. At the same time, CEOs with large stockholdings have a high exposure to noise in returns. They may then receive more earnings-based pay such as bonus pay. No prediction is thus made for $\delta_{14}$.

- **CEO chairman** $Chair_{i,t}$. This dummy variable equals 1 if the CEO is the chairman of the board of directors, and 0 otherwise. If CEOs receive the chairman title because of their superior performance (Vancil, 1987), bonus awards are expected to relate positively to the presence of a CEO-chairman. Hence $\delta_{15}$ is expected to be positive.

- **CEO tenure** $Tenure_{i,t}$. This variable is the natural logarithm of the number of years between the time the CEO of firm $i$ is appointed and $t$. Zhou and Swan (2003) argue that incentive pay partly depends on the monitoring role of the board of directors. Board independence, which determines board monitoring, declines with CEO tenure (Hermalin and Weisbach, 1988). If board monitoring decreases with CEO tenure, bonus awards are expected to be positively related to CEO tenure, and $\delta_{16}$ should be positive.

- **Number of board meetings** $Meet_{i,t}$. The monitoring role of the board of directors is potentially influenced by the number of board meetings. If board monitoring decreases as the number of board meetings declines, bonus awards are more likely when the number of board meetings is lower. Thus $\delta_{17}$ is expected to be negative.

- **Interlocked CEOs** $Interlock_{i,t}$. This dummy variable equals 1 if the CEO is interlocked, and 0 otherwise. Board monitoring likely is influenced by whether or not the CEO is interlocked (Hallock, 1997). If boards with an interlocked

CEO are less independent and less likely to perform their monitoring role, CEO bonus awards are positively related to the presence of an interlocked CEO, and $\delta_{18}$ is expected to be positive.

Table G.17 shows the results from estimating the model in (3.2). Marginal effects are displayed, since the estimated slope coefficients cannot be interpreted as in a linear regression.[5] Most variables yield significant coefficients with the predicted signs. Firms that perform better, in terms of exceeding earnings thresholds and generating shareholder value, firms in industries more likely to award a bonus, larger firms, firms with more growth options, and firms with a CEO-chairman are more likely to award a bonus to their CEO. On the other hand, firms with higher debt, riskier firms, firms with larger CEO stockholdings, firms whose CEO has longer tenure, and firms with interlocked CEOs are less likely to allocate a bonus to their CEO.

There are two sets of novel results in Table G.17 compared to the prior literature (see for instance Zhou and Swan (2003)). First, earnings thresholds play an important role in determining CEO bonus pay. The evidence indicates that both the sign of earnings (captured by $DA_{i,t}$) and the change in earnings (given by $Threshold_{A_{i,t}}$) matter. The coefficient on $Threshold_{A_{i,t}}$ is 0.474 ($\chi^2$-statistic of 190.05). When contemporaneous earnings exceed 80% of prior-year earnings and the dummy variable $Threshold_{A_{i,t}}$ changes from 0 to 1, the probability of the CEO earning a bonus increases by 0.119, as indicated by the marginal effect in column (2). The coefficient

[5]For continuous variables, marginal effects are computed as $\phi(x_{i,t}\widehat{\delta_x})\widehat{\delta_x}$, where $\phi(x_{i,t}\widehat{\delta_x})$ the probability density function of the standard normal distribution, following Greene (1997). The marginal effect is calculated for every observation $x_{i,t}$, and the reported marginal effects are the sample averages of the individual marginal effects. For dummy variables, marginal effects are computed by subtracting the predicted probability when the dummy of interest is 1 from the predicted probability when the dummy of interest is 0, while taking all the other variables at their mean values.

on $DA_{i,t}$ is $-0.569$ ($\chi^2$-statistic of 137.43). As contemporaneous earnings become negative, and the dummy $DA_{i,t}$ changes from 0 to 1, the probability of a CEO earning a bonus declines by 0.159.

CEO bonus contracts generally include a performance standard, and CEOs earn a bonus only if earnings exceed this standard (Murphy, 2000). Since many firms use prior-year earnings as a performance standard (Murphy, 2000), it is not surprising to find that the change in earnings is significant in determining CEO bonus awards. What is more surprising is that the sign of earnings matters, and that its economic significance is larger than that of the change in earnings. Table G.17 shows that the marginal effect of $DA_{i,t}$ is about 33% larger than the marginal impact of $Threshold_{A_{i,t}}$. There are two explanations for this result. First, firms oftentimes use more than one performance standard, and it is possible that the level of earnings correlates with an omitted performance standard. Performance standards are to a large extent unobservable, since most of them involve budgets (Murphy, 2000). Second, it is possible that compensation committees adjust bonus pay ex post. Murphy and Oyer (2003) show that compensation committees often deviate from CEO bonus pay contracts when awarding a bonus to their CEO. Such an explanation is also consistent with Degeorge et al. (1999), who argue that individuals frequently use zero as a reference point.

The second set of novel results concerns firm and CEO characteristics that the previous literature has not considered. For instance, firm characteristics such as past returns, the number of board meetings, and the pay practices in the firm's industry, as well as CEO characteristics such as the presence of a CEO-chairman, the presence of an interlocked CEO, CEO stock ownership and CEO tenure have so far not been taken into account in the determination of CEO bonus awards.

This thesis finds that most of these variables play an important role in CEO bonus awards. Furthermore, the coefficients on the governance variables are generally not consistent with CEOs being entrenched and preventing the board from effectively exercising its monitoring role. For instance, CEOs with longer tenure, and with more interlocking relations are *less* likely to earn a bonus, and not more likely, as would be predicted under entrenchment.

**Second stage: the pay-performance sensitivity to earnings**

The estimated slope coefficients from the first stage of the Heckman model, $\widehat{\delta_x}$, are used to compute the inverse Mills ratio, defined as the ratio of $\phi(\widehat{\delta_x} x_{i,t})$ to $\Phi(\widehat{\delta_x} x_{i,t})$, where $x_{i,t}$ are the independent variables from the probit model, and $\phi(\cdot)$ $[\Phi(\cdot)]$ is the standard normal probability density [cumulative distribution] function. The inverse Mills ratio is then included as an independent variable in the second-stage regression of the Heckman model. This second-stage regression is the main empirical model from equation (2.1), except that only observations where CEOs earn a bonus are considered. Consequently, the sample declines by about 25%. Table G.18 displays the results in Panel A (B) when the estimation risk proxy is $Disp_{i,t-1}$ $(||r_{i,t-\tau}||)$. The $t$-statistics are adjusted for heteroscedasticity, and for the fact that the regression includes an estimated variable (the inverse Mills ratio), following a procedure detailed in Greene (1997).

The two panels indicate that the principal findings of this thesis hold after controlling for the lower bonus bound. The sensitivity of CEO cash pay to earnings is lower when estimation risk is higher. For example, Panel A shows that the effect of $Disp_{i,t-1}$ on the weight on earnings is $-0.398$ ($t$-statistic of $-3.51$). In both panels, the coefficient $\lambda$ on the inverse Mills ratio is negative and significant at the 1% level.

This result indicates that sample selection matters, and has to be corrected for using a procedure such as a two-step Heckman estimation model. Overall, the evidence in Table G.18 suggests that the findings in this thesis are not substantially affected by the non-linearity inherent in CEO bonus pay contracts, and that they hold when only the linear portion of this contract is considered.

### 3.2.2 The effect of upper bonus bounds

In addition to the lower bonus bound, bonus contracts can include an upper bonus bound which caps CEO bonus pay. Since upper bonus bounds are not directly observable, two proxies for these upper bonus bounds are constructed. The first proxy is based on the observation that firms frequently follow industry practices when setting CEO cash pay (Bizjak et al., 2003). Hence, the level of earnings at which the upper bonus is capped likely is similar across firms in the same industry, for any given year. In addition, firms whose upper bonus bound is binding have relatively high earnings. Thus, the first proxy $D^I_{i,t}$ is a dummy variable that equals 1 if firm $i$ in year $t$ belongs to the highest quintile of the earnings distribution across all firms in the same 2-digit SIC industry, and 0 otherwise.

The second proxy $D^A_{i,t}$ is based on the observation that firms frequently cap their CEO bonus awards at 120% of prior-year earnings (Murphy, 1999, 2000). Hence $D^A_{i,t}$ is a dummy variable that equals 1 when earnings $A_{i,t}$ are higher than 120% of prior-year earnings $A_{i,t-1}$, and 0 otherwise. Both $D^I_{i,t}$ and $D^A_{i,t}$ are interacted with earnings $A_{i,t}$ to examine the effect of the upper bonus bound on the sensitivity of CEO cash pay to earnings, and on the main results of this thesis. If there is an upper bonus bound and if $D^I_{i,t}$ and $D^A_{i,t}$ are appropriate proxies for this upper bound, the coefficients on $A_{i,t}D^I_{i,t}$ and on $A_{i,t}D^A_{i,t}$ are expected to be negative, because the pay-performance relation is less strong once earnings exceed the upper bonus bound. Furthermore, the coefficients on $D^I_{i,t}$ and on $D^A_{i,t}$ are expected to be positive, since the upper bonus bound adds a fixed component to CEO pay that does not vary with performance.

The results from considering the upper bonus bound are shown in Table G.19, when the estimation risk proxy is the dispersion of analysts' forecasts $Disp_{i,t-1}$ (in Panel A), or past returns $||r_{i,t-\tau}||$ (in Panel B). The same two-stage Heckman estimation methodology as in Section 3.2.1 is used, because this technique controls for the presence of a lower bonus bound. Column (1) [column (2)] displays the results when $D^I_{i,t}$ [$D^A_{i,t}$] is the upper bonus bound proxy. In both cases, the sensitivity of CEO cash pay to earnings decreases as estimation risk rises. For instance, column (1) in Panel A shows that the coefficient $b_1$ on earnings interacted with the dispersion of analysts' forecasts $A_{i,t}Disp_{i,t-1}$ is $-0.367$ ($t$-statistic of $-3.23$).

Table G.19 thus indicates that controlling for the upper bonus bound does not substantially affect the main findings of this thesis. There are two reasons for this result. First, it is possible that most sample firms do not have an upper bonus bound, consistent with the evidence in Healy (1985) and Gaver et al. (1995). In fact, the evidence in Table G.19 supports this conjecture, since the interaction between earnings $A_{i,t}$ and the upper bonus bound proxies $D^I_{i,t}$ and $D^A_{i,t}$ does not yield the predicted negative coefficient $d_1$. Both panels indicate that $d_1$ is positive, and significantly so when $D^A_{i,t}$ is the upper bonus bound proxy (as shown in column (2)). Assuming that at least one of the two proxies $D^I_{i,t}$ or $D^A_{i,t}$ captures the upper bonus bound if it is widely used, this evidence suggests that few firms rely on such upper bounds. Second, the main results of the thesis can also be unaffected by the inclusion of the upper bonus bound proxies if the thesis already controls for the upper bonus bounds through its control variables and its fixed effects estimation technique.

## 3.3 Sensitivity analysis

This section analyzes the sensitivity of the main results in Tables G.4 and G.5 to a different regression estimation method, to alternative definitions for the explanatory variables, and to various subsamples.

### 3.3.1 The first difference specification

The paper relies on the level specification (where the level of CEO cash pay is the dependent variable) to test its main hypothesis. Because the level specification is estimated using fixed effects, it captures both time-series and cross-sectional variation in panel data, which arises from unobserved CEO characteristics, such as education. To estimate panel data models, the econometrics literature proposes an alternative to fixed effects analysis, namely the first difference specification, which is quite commonly used in the compensation literature. Econometrically, neither the fixed effects nor the first difference specification is preferred. Greene (2001) cautions that the first difference specification can introduce autocorrelation into the error term. The first difference specification estimates the same underlying structural model as the fixed effect specification, the only difference being the manner in which variables are adjusted to take into account the panel structure of the data. In the first difference specification, the change in the dependent variable is regressed on the change in the independent variables from the level specification.

The main regression model outlined in equation (2.1) is re-estimated using the first difference of all the regression variables instead of their levels. Table G.20 reports the results in Panel A (B) when the estimation risk proxy is $Disp_{i,t-1}$ ($||r_{i,t-\tau}||$). The number of observations falls by about 25%, because all variables are now defined in terms of changes. The evidence continues to show that the weight on earnings declines when estimation is higher. For example, Panel A indicates that the coefficient $b_1$ on earnings interacted with the dispersion of analysts' forecasts $A_{i,t}Disp_{i,t-1}$ is significantly negative, at $b_1 = -0.345$ ($t$-statistic of $-2.37$).

### 3.3.2 Alternative explanatory variables

First, the impact of the return measure is investigated. Market-adjusted returns, with the market defined as the value-weighted index instead of the equally-weighted index, are examined. Also, annual returns are obtained not by cumulating monthly returns over 12 months, but by computing buy-and-hold returns over 12 months. Next, unadjusted raw stock returns are considered. The results hold. Second, two alternative earnings measures are analyzed. Instead of defining earnings as income before extraordinary items and discontinued operations (COMPUSTAT #18), earnings are defined as earnings before special items (COMPUSTAT #18 - COMPUSTAT #17), and as net income (COMPUSTAT #172). The inferences are unchanged.

Moreover the thesis uses alternative ways to control for growth options. Firms with large shocks likely have numerous growth options, and thus may use earnings-based bonus plans to a lesser extent. Although the thesis controls for the effect of growth options on the sensitivity of CEO cash pay to earnings by including the book-to-market ratio $B/M_{i,t}$ in its empirical analysis, it is possible that the book-to-market ratio is not an adequate control for growth options. This issue is addressed in several ways. First, the thesis recomputes its main results using standardized prediction errors as a proxy for past shocks. Standardized prediction errors are calculated following Kothari and Warner (1997). First, the market model is estimated using monthly data over the 60 months preceding the first year prior to the sample year. Next, monthly abnormal returns are computed for the year prior to the sample year using the intercept and slope coefficient estimated in the first step as well as the returns realized during the year prior to the sample year. Monthly abnormal returns are cumulated over the year prior to the sample year to yield annual abnormal returns. Finally, annual abnormal returns are scaled by the annualized standard error of the market model residual estimated in the first step to obtain the standardized prediction errors. The main findings hold. Undisplayed results show that as standardized prediction errors in the year prior to the sample year become more extreme, the weight on earnings falls.

Furthermore, it is possible that a continuous measure of the book-to-market ratio does not appropriately control for the effect of growth options on the weight on earnings. Hence, the thesis uses a dummy variable to capture extreme values of growth options. The results of the thesis generally hold when different deciles of the growth options variable are used as a cutoff for the dummy variable. Furthermore, the findings also hold when this exercise is repeated for the CEO ownership variable.

Next, the thesis uses the standard deviation of monthly stock returns, $Vol_{i,t}$, as a control variable for the weight on earnings. Remember from the correlation analysis in Table G.3 that the correlation between $Vol_{i,t}$ and the two estimation risk proxies is fairly strong. Undisplayed results show that the main findings of this thesis generally hold. Finally, the thesis allows for an asymmetric response of CEO cash pay to positive and negative returns. Leone et al. (2006) show that CEO cash pay is more sensitive to returns when returns are negative than when they are positive. After controlling for the increased sensitivity to returns when returns are negative, the main results of this thesis hold.

### 3.3.3 Different subsamples

First, the effect of removing financial institutions (SIC code 6000 – 6999) and utilities (SIC code 4911 – 4991) is investigated. Financial institutions and utilities are regulated, which may affect the relation between CEO cash pay and earnings (Leone et al., 2006). The findings are unchanged. Furthermore, the effect of removing founders is examined. Joos et al. (2003) document that about 25% of the CEO-years are founders, family members of founders, or became CEO through a corporate control transaction. They find that for such CEO-founders, the pay-performance sensitivity to earnings is lower. After removing CEO-founders from the sample, the main results of this thesis hold.

# Conclusion

Most CEO cash pay contracts are based on earnings. Earnings introduce risk into CEO cash pay that results from fluctuations in earnings noise, which captures items in earnings not resulting from CEO effort. The executive compensation literature has traditionally assumed that the parameters of the earnings noise distribution are known when next year's CEO cash pay is set. In reality however, this assumption is unlikely to hold. The CEO and the compensation committee, who together set earnings-based CEO cash pay for the year ahead, likely do not know the parameters of the earnings noise distribution. This thesis therefore analyzes the more general case when the parameters of the earnings noise distribution are not known, and there is estimation risk.

This thesis starts by presenting a standard principal-agent model to which it adds uncertainty about the parameters of the earnings noise distribution. The CEO and the compensation committee learn about the unknown parameters of the earnings noise distribution in a Bayesian manner. They update their beliefs about these parameters using past earnings noise realizations. Since the CEO's optimal past effort is known, past earnings noise realizations can be backed out of past earnings observations. When the CEO and the compensation committee have a longer record of past earnings noise observations, they can estimate the parameters of the earnings noise distribution in a more precise manner, and estimation risk falls. The model in this thesis then predicts that the weight on earnings rises as estimation risk declines. Two estimation risk proxies are used to test this prediction.

The first estimation risk proxy is the dispersion of analysts' forecasts. Analysts likely have less information about the firm when the CEO and the compensation committee have a shorter record of past earnings noise realizations. Hence when estimation risk rises, analysts' opinions diverge to a larger extent and the dispersion of their forecasts for the year ahead earnings rises. Therefore, the thesis predicts that the weight on earnings falls with the dispersion of analysts' forecasts for the year ahead earnings. The evidence supports this prediction.

The second proxy for estimation risk relies on economic shocks. Next year's earnings noise is affected by current shocks since earnings lack timeliness. When the CEO and the compensation committee set earnings-based CEO cash pay for the year ahead, they likely can observe shocks that will affect next year's earnings noise distribution. Shocks to the earnings noise distribution re-introduce uncertainty about its parameters, so that the CEO and the compensation committee have to learn again. To do so, they look at how similar past shocks have affected past earnings noise. When shocks are more extreme, the CEO and the compensation committee have a shorter record of how similar past shocks have affected past earnings noise. Shocks indeed occur less often as they become more extreme. Consequently, when shocks are larger, learning about the parameters of the earnings noise distribution is more difficult and estimation risk rises. The thesis therefore hypothesizes that the weight on earnings is lower when past shocks are more extreme. Using the absolute value of past stock returns to capture the size of past shocks independent of their sign, the thesis finds support for this prediction.

Economic shocks are recognized in earnings over a period of several years, as evidenced by the positive correlation between earnings and past returns. Over time, the CEO and the compensation committee thus have an longer record of how a specific shock has already affected past earnings noise. The CEO and the compensation committee then learn about the effect of this particular shock on the parameters of the earnings noise distribution as time goes by, and estimation risk falls. Therefore, the thesis predicts that the decline in the weight on earnings for more extreme past shocks is more important for shocks from the more recent past than for shocks from further in the past. The evidence provides some support for this prediction.

Companies often include subjective and non-financial performance measures in CEO cash pay contracts. Compensation theory suggests that, under certain conditions, the relative weight on subjective and non-financial performance measures increases as estimation risk about the earnings noise distribution rises. To test this prediction, this thesis examines 196 firms that experience large economic shocks and have high estimation risk as well as 196 matched control firms that are not subject to such shocks. The analysis indicates that following large shocks when estimation risk is high, firms shift the weight onto subjective performance measures. This evidence suggests that when compensation committees cannot estimate the parameters of the earnings noise distribution in a precise manner, they wait until earnings have been realized to then determine CEO cash pay subjectively.

The main contribution of this thesis is that it extends the understanding of risk related to earnings noise. Traditionally, researchers have assumed that the parameters of the earnings noise distribution are known when CEO cash pay for the year ahead is set, and there is no estimation risk. This thesis shows, both theoretically and empirically, that such estimation risk can substantially affect the weight on earnings, even after controlling for sources of risk in earnings other than estimation risk. This result suggests that it is important for researchers to take into account estimation risk, especially in situations where estimation risk is high. To do so, researchers can use estimation risk proxies such as the dispersion of analysts' forecasts or the size of past returns.

# Bibliography

Aggarwal, R. K. and A. A. Samwick (1999). The other side of the trade-off: the impact of risk on executive compensation. *Journal of Political Economy 107*(1), 65–105.

Ali, A. and P. Zarowin (1992). Permanent versus transitory components of annual earnings and estimation error in earnings response coefficients. *Journal of Accounting and Economics 15*, 249–264.

Ang, J. S., R. A. Cole, and J. W. Lin (2000). Agency costs and ownership structure. *The Journal of Finance 55*(1), 81–106.

Astec Industries (1999). Schedule 14 A.

Baber, W. R., S. N. Janakiraman, and S.-H. Kang (1996). Investment opportunities and the structure of executive compensation. *Journal of Accounting and Economics 21*, 297–318.

Baber, W. R., S.-H. Kang, and K. R. Kumar (1998). Accounting earnings and executive compensation: the role of earnings persistence. *Journal of Accounting and Economics 25*, 169–193.

Baiman, S. and M. V. Rajan (1995). The informational advantages of discretionary bonus schemes. *The Accounting Review 70*(4), 557–579.

Baker, G. P., R. Gibbons, and K. J. Murphy (1994). Subjective performance measures in optimal incentive contracts. *The Quarterly Journal of Economics 109*(4), 1125–1156.

Balke, N. S. and T. B. Fomby (1991). Shifting trends, segmented trends, and infrequent permanent shocks. *Journal of Monetary Economics 28*, 61–85.

Balke, N. S. and T. B. Fomby (1994). Large shocks, small shocks, and economic fluctuations: outliers in macroeconomic time-series. *Journal of Applied Econometrics 9*, 181–200.

Banker, R. D. and S. Datar (1989). Sensitivity, precision and linear aggregation of signals for performance evaluation. *Journal of Accounting Research*, 21–39. Spring.

Barclay, M. J., D. Gode, and S. Kothari (2005). Measuring delivered performance. *Journal of Contemporary Accounting and Economics 1*, 1–25.

Barry, C. B. and S. J. Brown (1985, December). Differential information and security market equilibirum. *Journal of Financial and Quantitative Analysis 20*, 407–422.

Basu, S. (1997, December). The conservatism principle and the asymmetric timeliness of earnings. *Journal of Accounting and Economics 24*, 3–37.

Beaver, W., R. Lambert, and D. Morse (1980). The information content of security prices. *Journal of Accounting and Economics 2*, 3–28.

Belsley, D., E. Kuh, and R. Welsch (1980). *Regression diagnostics: identifying influential data and sources of collinearity.* New York: John Wiley and Sons.

Bizjak, J. M., M. L. Lemmon, and L. Naveen (2003). Does the use of peer groups contribute to higher pay and less efficient compensation? Working Paper.

Brennan, M. and A. Subramanyam (1995). Investment analysis and price formation in securities markets. *Journal of Financial Economics 38*, 361–81.

Brickley, J. A., J. L. Coles, and G. Jarrel (1997). Leadership structure: separating the CEO and chairman of the board. *Journal of Corporate Finance 3*, 189–220.

Burgstahler, D., J. Jiambalvo, and T. Shevlin (2002, June). Do stock prices fully reflect the implications of special items for future earnings? *Journal of Accounting Research 40*, 585–612.

Bushman, R. M., R. J. Indjejikian, and A. J. Smith (1996). CEO compensation: the role of individual performance evaluation. *Journal of Accounting and Economics 21*, 161–193.

Bushman, R. M. and A. J. Smith (2001). Financial accounting information and corporate governance. *Journal of Accounting and Economics 32*, 237–333.

Chamley, C. P. (2004). *Rational herds: economic models of social learning.* Cambridge: Cambridge University Press.

Clement, M. B. (1999). Analyst forecast accuracy: do ability, resources and portfolio complexity matter? *Journal of Accounting and Economics 27*, 285–303.

Collins, D. W., S. Kothari, J. Shanken, and R. G. Sloan (1994). Lack of timeliness and noise as explanations for the low contemporaneous return-earnings association. *Journal of Accounting and Economics 18*, 289–324.

Core, J. E. and W. R. Guay (1999). The use of equity grants to manage optimal equity incentive levels. *Journal of Accounting and Economics 28*, 151–184.

Core, J. E., W. R. Guay, and R. Verrecchia (2003). Price versus non-price performance measures in optimal CEO compensation contracts. *The Accounting Review 78*, 957–981.

Core, J. E., R. W. Holthausen, and D. F. Larcker (1999). Corporate governance, chief executive officer compensation, and firm performance. *Journal of Financial Economics 51*, 371–406.

Cygnus Inc. (1995). Schedule 14 A.

Datar, S., S. C. Kulp, and R. A. Lambert (2001, June). Balancing performance measures. *Journal of Accounting Research 39*(1), 75–92.

Deckop, J. R. (1988, January). Determinants of chief executive officer compensation. *Industrial and Labor Relations Review 41*(2), 215–226.

Degeorge, F., J. Patel, and R. Zeckhauser (1999). Earnings management to exceed thresholds. *Journal of Business 72*(1), 1–33.

Demsetz, H. and K. Lehn (1985). The structure of corporate ownership: causes and consequences. *Journal of Political Economy 93*(6), 1155–1177.

Dewatripoint, M., I. Jewitt, and J. Tirole (1999). The economics of career concerns, part I: comparing information structures. *Review of Economic Studies 66*, 183–198.

Frankel, R., S. Kothari, and J. Weber (2006). Determinants of the informativeness of analyst research. *Journal of Accounting and Economics 41*, 29–54.

Gaver, J. J., K. M. Gaver, and J. R. Austin (1995). Additional evidence on bonus plans and income management. *Journal of Accounting and Economics 19*, 3–28.

Gibbons, R. and K. J. Murphy (1992). Optimal incentive contracts in the presence of career concerns: theory and evidence. *Journal of Political Economy 100*(3), 468–505.

Gibbs, M., K. A. Merchant, W. A. V. D. Stede, and M. E. Vargus (2004). Determinants and effects of subjectivity in incentives. *The Accounting Review 79*(2), 409–436.

Greene, W. H. (1997). *Econometric analysis.* New Jersey: Prentice-Hall.

Greene, W. H. (2001, January). Fixed and random effects in nonlinear models. Working Paper, New York University.

Gu, Z. and J. S. Wu (2003). Earnings skewness and analyst forecast bias. *Journal of Accounting and Economics 35*, 5–29.

Hallock, K. (1997, September). Reciprocally interlocking boards of directors and executive compensation. *Journal of Financial and Quantitative Analysis 32*(3), 331–344.

Hayes, R. M. and S. Schaefer (2000). Implicit contracts and the explanatory power of top executive compensation for future performance. *Rand Journal of Economics 31*(2), 273–293.

Hayn, C. (1995). The information content of losses. *Journal of Accounting and Economics 20*, 125–153.

Healy, P. M. (1985, April). The effect of bonus schemes on accounting decisions. *Journal of Accounting and Economics 7*, 85–107.

Healy, P. M., A. P. Hutton, and K. G. Palepu (1999). Stock performance and intermediation changes surrounding sustained increases in disclosure. *Contemporary Accounting Research 16*(3), 485–520.

Hermalin, B. E. and M. S. Weisbach (1988). The determinants of board composition. *The Rand Journal of Economics 19*(4), 589–606.

Hermalin, B. E. and M. S. Weisbach (2001, March). Boards of directors as an endogenously determined institution: a survey of the economic literature. NBER Working Paper Nr. 8161.

Holmström, B. (1979). Moral hazard and observability. *The Bell Journal of Economics 10*, 74–91.

Holmström, B. (1999). Managerial incentive problems: a dynamic perspective. *Review of Economic Studies 66*, 169–182.

Holmström, B. and P. Milgrom (1987). Aggregation and linearity in the provision of intertemporal incentives. *Econometrica 55*(2), 303–328.

Holmström, B. and P. Milgrom (1991). Multitask principal-agent analyses: incentive contracts, asset ownership and job design. *Journal of Law, Economics, & Organization 7*, 24–52.

Indjejikian, R. J. and D. Nanda (2002, October). Executive target bonuses and what they imply about performance standards. *The Accounting Review 77*(4), 793–819.

Ittner, C. D., D. F. Larcker, and M. W. Meyer (2003, July). Subjectivity and the weighting of performance measures: evidence from a balanced scorecard. *The Accounting Review 78*(3), 725–757.

Ittner, C. D., D. F. Larcker, and M. V. Rajan (1997, April). The choice of performance measures in annual bonus contracts. *The Accounting Review 72*(2), 231–255.

Jeffreys, H. S. (1961). *Theory of probability.* Oxford: Oxford University Press.

Jin, L. (2002). CEO compensation, diversification, and incentives. *Journal of Financial Economics 66*, 29–63.

Joos, P., A. Leone, and J. Zimmerman (2003). Selecting CEOs: matching the person to the job. Working paper, University of Rochester.

Joskow, P. L. and N. L. Rose (1994, December). CEO pay and firm performance: dynamics, asymmetries and alternative performance measures. NBER Working Paper No. 4976.

Kalymon, B. A. (1971, January). Estimation risk in the portfolio selection model. *Journal of Financial and Quantitative Analysis 6*, 259–282.

Kothari, S. and J. B. Warner (1997). Measuring long-horizom security prices. *Journal of Financial Economics 43*, 301–339.

Lambert, R. A. (1993). The use of accounting and security price measures of performance in managerial compensation contracts: a discussion. *Journal of Accounting and Economics 16*, 102–121.

Lambert, R. A. (2001). Contracting theory and accounting. *Journal of Accounting and Economics 32*, 3–87.

Lambert, R. A. and D. F. Larcker (1987). An analysis of the use of accounting and market measures of performance in executive compensation contracts. *Journal of Accounting Research 25 (Supplement)*, 85–125.

Lang, M. H. (1991). Time-varying stock price response to earnings induced by uncertainty about the time-series process of earnings. *Journal of Accounting Research 29*(2), 229–257.

Lang, M. H. and R. L. Lundholm (1996). Corporate disclosure policy and analyst behavior. *The Accounting Review 71*(4), 467–492.

Lee, P. M. (1989). *Bayesian Statistics: An introduction.* New York: Oxford University Press.

Leone, A. J. and S. Rock (2002). Empirical tests of budget ratcheting and its effect on managers' discretionary accrual choices. *Journal of Accounting and Economics 33*, 43–67.

Leone, A. J., J. S. Wu, and J. L. Zimmerman (2006, October). Asymmetric sensitivity of CEO cash compensation to stock returns. *Journal of Accounting and Economics 42*, 167–192.

Lev, B. (1983). Some economic determinants of time-series properties of earnings. *Journal of Accounting and Economics 5*, 31–48.

Lewellen, J. and J. Shanken (2002). Learnings, asset-pricing tests and market efficiency. *The Journal of Finance 57*, 1113–1145.

Markov, S. and A. Tamayo (2006). Predictability in financial analyst forecast errors: learning or irrationality? *Journal of Accounting Research 44*(4), 725–761.

Mikhail, M. B., B. R. Walther, and R. R. Willis (1997). Do security analysts improve their performance with experience? *Journal of Accounting Research 35 (Supplement)*, 131–157.

Milgrom, P. and J. Roberts (1992). *Economics, organization and management.* Englewood Cliffs, New Jersey 07632: Prentice Hall.

Murphy, K. J. (1985). Corporate performance and managerial remuneration: an empirical analysis. *Journal of Accounting and Economics 7*, 11–42.

Murphy, K. J. (1986). Incentives, learning and compensation: a theoretical and empirical investigation of managerial labor contracts. *The Rand Journal of Economics 17*(1), 59–76.

Murphy, K. J. (1999). Executive compensation. In A. Orley and D. Card (Eds.), *Handbook of Labor Economics*, Volume 3. North-Holland, Amsterdam.

Murphy, K. J. (2000). Performance standards in incentive contracts. *Journal of Accounting and Economics 30*, 245–278.

Murphy, K. J. and P. Oyer (2003). Discretion in executive incentive contracts. Working Paper, University of Southern California.

Natarajan, R. (1996). Stewardship value of earnings components: additional evidence on the determinants of executive compensation. *The Accounting Review 71*, 1–22.

National Computer Systems Inc. (1999). Schedule 14 A.

O'Brien, P. (1988). Analysts' forecasts as earnings expectations. *Journal of Accounting and Economics 10*, 53–83.

Parametric Technology Corp (2003). Schedule 14 A.

Robert, C. P. (1994). *The Bayesian Choice: a decision-theoretic motivation.* New York: Springer-Verlag.

Royal Appliance MFG Co (2003). Schedule 14 A.

Sloan, R. G. (1993). Accounting earnings and top executive compensation. *Journal of Accounting and Economics 16*, 55–100.

Smith, C. W. and R. L. Watts (1992). The investment opportunity set and corporate financing, dividend, and compensation policies. *Journal of Financial Economics 32*, 263–292.

Sung, J. (1995). Linearity with project selection and controllable diffusion rate in continuous-time principal-agent problems. *Rand Journal of Economics 26*(4), 720–743.

Vancil, R. F. (1987). *Passing the baton: managing the process of CEO succession.* Boston: Harvard Business School Press.

Warfield, T. D. and J. J. Wild (1992). Accounting recognition and the relevance of earnings as an explanatory variable for returns. *The Accounting Review 67*(4), 821–842.

Womack, K. L. (1996, March). Do brokerage analysts' recommendations have investment value? *The Journal of Finance 51*(1), 137–167.

Wooldridge, J. M. (2005). Fixed-effects and related estimators for correlated random-coefficient and treatment-effect panel data models. *The Review of Economics and Statistics 87*(2), 385–396.

Zellner, A. (1971). *An introduction to Bayesian Inference in Econometrics.* New York: John Wiley & Sons, Inc.

Zhou, X. and P. L. Swan (2003). Performance thresholds in managerial incentive contracts. *Journal of Business 76*(4), 665–696.

# Appendix A

# The predictive distribution for noise in next year's earnings

This appendix provides the proof that the noise in next year's earnings is distributed normally, with a mean $\bar{x}$, and a variance $\sigma^2(1+\frac{1}{n})$. To start, suppose that earnings for the year ahead $A$ are a noisy signal of CEO effort $e$, that is $A = e + x$, where $x$ is the noise from a population that is normally distributed with a mean $\theta$ and a variance $\sigma^2$. The mean $\theta$ of the noise distribution is assumed to be unknown. The variance $\sigma^2$ of the noise distribution is assumed to be known. The compensation committee and the CEO have an uninformative prior about the unknown mean $\theta$. After observing $n$ past observations of the noise $x$, they update their prior according to Bayes' rule, and form their posterior for $\theta$. It can be shown that this posterior is distributed normally with a mean $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$ and a variance $\frac{\sigma^2}{n}$ (Zellner, 1971; Lee, 1989). Given the posterior distribution for $\theta$, the predictive distribution for the next observation of noise, $x_{n+1}$ (the noise in next year's earnings), can be derived. The probability density function (henceforth "pdf") for $x_{n+1}$, given $\theta$, $\sigma^2$, and the sample information $\mathbf{x} = x_1, ..., x_n$ is as follows:

$$p(x_{n+1}|\theta, \sigma^2, \mathbf{x}) = \frac{1}{\sqrt{2\Pi}\sigma} exp[-\frac{1}{2\sigma^2}(x_{n+1} - \theta)^2].$$

Similarly, the posterior pdf for the unknown mean $\theta$ given $\sigma^2$, and the sample information $\mathbf{x} = x_1, ..., x_n$ is:

$$p(\theta|\sigma^2, \mathbf{x}) = \frac{\sqrt{n}}{\sqrt{2\Pi}\sigma} exp[-\frac{n}{2\sigma^2}(\theta - \bar{x})^2].$$

Hence, the predictive pdf for the next noise observation $x_{n+1}$, $p(x_{n+1}|\mathbf{x})$, can be written as:

$$\begin{aligned} p(x_{n+1}|\mathbf{x}) &= \int_{-\infty}^{+\infty} p(x_{n+1}|\theta, \sigma^2, \mathbf{x}) p(\theta|\sigma^2, \mathbf{x}) d\theta \\ &= \int_{-\infty}^{+\infty} \frac{\sqrt{n}}{2\Pi\sigma^2} exp[-\frac{1}{2\sigma^2}((x_{n+1} - \theta)^2 + n(\theta - \bar{x})^2)] d\theta. \quad \text{(A.1)} \end{aligned}$$

The last term in the integrand in equation (A.1), $(x_{n+1} - \theta)^2 + n(\theta - \bar{x})^2$, can be rewritten as follows:

$$\begin{aligned} (x_{n+1} - \theta)^2 + n(\theta - \bar{x})^2 &= x_{n+1}^2 + (n+1)\theta^2 - 2\theta(x_{n+1} + n\bar{x}) + n\bar{x}^2 \\ &= (n+1)[\theta^2 - \frac{2\theta(x_{n+1} + n\bar{x})}{n+1}] + n\bar{x}^2 + x_{n+1}^2 \\ &= (n+1)(\theta - \frac{x_{n+1} + n\bar{x}}{n+1})^2 - \frac{(x_{n+1} + n\bar{x})^2}{n+1} + n\bar{x}^2 + x_{n+1}^2 \\ &= (n+1)(\theta - \frac{x_{n+1} + n\bar{x}}{n+1})^2 + \frac{n(x_{n+1} - \bar{x})^2}{n+1}. \quad \text{(A.2)} \end{aligned}$$

Substituting the last expression from equation (A.2) into equation (A.1) yields:

$$\begin{aligned} p(x_{n+1}|\mathbf{x}) &= \int_{-\infty}^{+\infty} \frac{\sqrt{n}}{2\Pi\sigma^2} exp[-\frac{1}{2\sigma^2}((n+1)(\theta - \frac{x_{n+1} + n\bar{x}}{n+1})^2 + \frac{n(x_{n+1} - \bar{x})^2}{n+1})] d\theta \\ &= \frac{\sqrt{n}}{2\Pi\sigma^2} exp[-\frac{n}{2\sigma^2(n+1)}(x_{n+1} - \bar{x})^2] \int_{-\infty}^{+\infty} exp[\frac{(\theta - \frac{x_{n+1}+n\bar{x}}{n+1})^2}{2\frac{\sigma^2}{n+1}}] d\theta \text{(A.3)} \end{aligned}$$

Recognizing that:

$$\frac{1}{\sqrt{2\Pi}\frac{\sigma}{\sqrt{n+1}}} \int_{-\infty}^{+\infty} exp[\frac{(\theta - \frac{x_{n+1}+n\bar{x}}{n+1})^2}{2\frac{\sigma^2}{n+1}}] d\theta$$

integrates to 1, since it is the area under a normal distribution with a mean of

$\frac{x_{n+1}+n\bar{x}}{n+1}$ and a variance of $\frac{\sigma^2}{n+1}$, the expression in (A.3) can be rewritten as follows:

$$\begin{aligned} p(x_{n+1}|\mathbf{x}) &= \frac{\sqrt{n}}{2\Pi\sigma^2} exp[-\frac{1}{2\sigma^2\frac{n+1}{n}}(x_{n+1}-\bar{x})^2]\sqrt{2\Pi}\frac{\sigma}{\sqrt{n+1}} \\ &= \frac{1}{\sqrt{2\Pi}\sigma\frac{\sqrt{n+1}}{\sqrt{n}}} exp[-\frac{1}{2\sigma^2\frac{n+1}{n}}(x_{n+1}-\bar{x})^2] \end{aligned}$$

Thus, the next observation of the noise distribution, $x_{n+1}$, is distributed normally with a mean $\bar{x}$ and a variance $\sigma^2(1+\frac{1}{n})$.

# Appendix B

# The prior for the mean of the noise distribution

This appendix analyzes the effect of estimation risk on CEO cash pay when the CEO and the compensation committee have a common prior that the unknown mean $\theta$ of the earnings noise distribution is normally distributed with a mean $\theta_0$ and a variance $\sigma_0^2$. Upon observing $n$ past earnings noise realizations up to year $t-1$, the CEO and the compensation committee form their posterior for the unknown mean $\theta$, which is normally distributed with a mean of $\theta_1 = (1-z)\theta_0 + z\bar{x}$ (Zellner, 1971; Lee, 1989). The posterior mean of $\theta$ depends not only on the sample mean $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$, as with an uninformative prior, but also on the prior mean, $\theta_0$. Furthermore, $z = \frac{\sigma_0^2}{\frac{\sigma^2}{n}+\sigma_0^2}$ is the weight assigned to the sample mean $\bar{x}$. As the record of past earnings noise observations rises, the CEO and the compensation committee put a larger weight $z$ on the sample mean $\bar{x}$. The variance of the posterior for $\theta$ is $\sigma_1^2 = \frac{\frac{\sigma^2}{n}\sigma_0^2}{\frac{\sigma^2}{n}+\sigma_0^2}$ (Lee, 1989), and reflects estimation risk. It depends on $\frac{\sigma^2}{n}$, and on the prior variance $\sigma_0^2$. The variance $\sigma_1^2$ rises when there are less past earnings noise realizations, as in the case of an uninformative prior, and when the prior variance $\sigma_0^2$ is larger.[1]

[1]The derivative of $\sigma_1^2$ with respect to $n$ is $\frac{\partial \sigma_1^2}{\partial n} = \frac{-\frac{\sigma^2}{n}\sigma_0^4}{(\frac{\sigma^2}{n}+\sigma_0^2)^2}$, which is strictly negative. Furthermore, $lim_{n\to 0^+}\sigma_1^2 = +\infty$. The derivative of $\sigma_1^2$ with respect to $\sigma_0^2$ is $\frac{\partial \sigma_1^2}{\partial \sigma_0^2} = \frac{(\frac{\sigma^2}{n})^2+2\frac{\sigma^2}{n}\sigma_0^2}{(\frac{\sigma^2}{n}+\sigma_0^2)^2}$, which is

Upon forming their posterior for the unknown mean $\theta$, the CEO and the compensation committee update their beliefs about the noise in year ahead earnings. This noise is normally distributed with a mean $\theta_1$ and a variance $\sigma^2 + \sigma_1^2$ (Zellner, 1971; Lee, 1989). Given this updated noise distribution, the optimal weight on earnings is $\beta = \frac{p'[e]}{1+rc''[e](\sigma^2+\sigma_1^2)}$. As with an uninformative prior, the optimal weight $\beta$ on earnings is lower when there is estimation risk, since the denominator for $\beta$ includes the additional variance $\sigma_1^2$. The weight on earnings $\beta$ falls with the number $n$ of past earnings noise observations, just as with the uninformative prior. Furthermore, the weight on earnings decreases when the variance of the prior $\sigma_0^2$ is larger.

---

strictly positive. Also, $lim_{\sigma_0^2 \to +\infty} \sigma_1^2 = +\infty$.

# Appendix C

# The lack of timeliness in earnings

This appendix explains why earnings are less timely than returns. Returns lead earnings because, in efficient markets, returns impound all publicly available information about changes in the firm's expected discounted future cash flows. Earnings, on the other hand, likely reflect information relating to such changes only at a later point in time, for three reasons.

First, not all expected future cash flows impounded in the firm's market value are recognized as assets and liabilities in its financial statements. For instance, expected future cash disbursements resulting from lawsuits are impounded in returns. However, they are recognized as contingent liabilities in the firm's financial statements only when it is probable that a liability has been incurred, and when the amount of the liability can be reasonably estimated. Furthermore, while the market value of a firm captures its brand name, the firm's recognized assets do not account for internally generated brand capital. This implies that a change in the value of the brand name, which is impounded in the firm's returns, is not reflected in its financial statements, at least not immediately. Rather, a change in the value of the firm's brand name will be recognized in its earnings over time, for example as its sales capture the effect of the change in the brand name.

Second, events reflecting changes in the expected future cash flows of assets and liabilities recognized in the firm's financial statements have not necessarily met the criteria for accounting recognition. For instance, because of the matching principle, expenses are recorded in the accounting period when the corresponding revenues are recognized. Therefore, increases in input prices that reduce the firm's expected future net cash flows are reflected gradually, through higher costs of goods sold. Warfield and Wild (1992) point towards a similar timing issue with long-term debt. Debt is initially recorded at the value consistent with the money market conditions in effect at the time of the issue, and subsequent interest costs reflected in the firm's financial statements are based on those initial issue-time money market conditions. If those conditions change after the issue, any holding losses (or gains) are not recorded until the firm actually extinguishes its debt.

Finally, earnings are not released continuously. Since shares are traded daily on stock exchanges, share prices reflect changes in the firm's expected future cash flows in a much more timely manner than earnings. The SEC requires publicly traded companies to compile financial reports on an annual and a quarterly basis.

# Appendix D

# Variable definition

All CEO compensation and return data are in 1992 constant U.S. dollars.

- $A_{i,t}$: income before extraordinary items and discontinued operations (COMPUSTAT #18) in $t$ scaled by total assets (COMPUSTAT #6) in $t-1$.
- $A_{i,t-1}$: income before extraordinary items and discontinued operations (COMPUSTAT #18) in $t-1$ scaled by total assets (COMPUSTAT #6) in $t-2$.
- $B/M_{i,t}$: natural logarithm of the firm's book value in $t-1$ divided by the firm's market value in $t-1$; the firm's book value is the book value of assets (COMPUSTAT #6); the firm's market value is the price per share at year end times the number of shares outstanding plus the book value of the firm's assets (COMPUSTAT #6) minus the book value of common equity (COMPUSTAT #60).
- $BonInd_{i,t}$: percentage of firms in firm $i$'s industry (defined by 2-digit SIC code) that award CEO bonus pay in $t$.
- $C_{i,t}$: natural logarithm of real CEO cash pay (in thousands of U.S. dollars), which is salary (EXECUCOMP: SALARY) plus bonus pay (EXECUCOMP: BONUS).

- $Cash_{i,t}$: common and preferred dividends (COMPUSTAT #19 and #21) plus investing cash flows (COMPUSTAT #311) minus operating cash flows (COMPUSTAT #308) scaled by prior-year total assets.
- $Chair_{i,t}$: dummy that equals 1 if the CEO is the chairman of the board of directors, and 0 otherwise. The chairman is identified by searching the CEO title (EXECUCOMP: TITLEANN) for "chmn" and "chairman".
- $CV$: matrix of control variables for the weight on earnings. $CV$ includes growth options $B/M_{i,t}$, noise in earnings relative to noise in returns $Risk_{i,t}$, earnings persistence $\psi_i$, CEO stock ownership $Own_{i,t}$, and CEO tenure $Tenure_{i,t}$.
- $D^A_{i,t}$: dummy that equals 1 if $A_{i,t}$ is higher than 120% of prior-year earnings, and 0 otherwise.
- $D^I_{i,t}$: dummy that equals 1 if $A_{i,t}$ belongs to the highest earnings quintile, by fiscal year and 2-digit SIC code, and 0 otherwise.
- $DA_{i,t}$: dummy that equals 1 if earnings $A_{i,t} < 0$, and 0 otherwise.
- $Debt_{i,t}$: debt ratio, defined as the sum of long-term debt (COMPUSTAT #9) and debt in current liabilities (COMPUSTAT #34) divided by current total assets (COMPUSTAT #6).
- $Disp_{i,t-1}$: standard deviation of analysts' forecasts made $t-1$ for earnings in $t$, divided by average absolute analysts' forecasts made during $t-1$ for earnings in $t$. This ratio is ranked across all observations.
- $Interlock_{i,t}$: dummy that equals 1 if the CEO is interlocked, and 0 otherwise, as indicated by the variable PINTRLOC on EXECUCOMP. EXECUCOMP defines CEOs as being interlocked if they are either on their firm's compensa-

tion committee, or on the board of a company managed by an executive who is on their own firm's board.

- $K$: matrix of control variables for the level of CEO pay. $K$ includes firm size $Size_{i,t}$, growth options $B/M_{i,t}$, firm risk $Vol_{i,t}$, the number of board meetings $Meet_{i,t}$, CEO stock ownership $Own_{i,t}$, CEO tenure $Tenure_{i,t}$, the presence of a CEO chairman $Chair_{i,t}$, and the presence of an interlocked CEO $Interlock_{i,t}$.
- $Meet_{i,t}$: number of board of directors meetings (EXECUCOMP: NUMMTGS) in $t$.
- $Risk_{i,t}$ (Lambert and Larcker, 1987): the ranked ratio of the risk in earnings to the risk in returns. Risk in earnings is the variance of earnings over the five years preceding $t$, while risk in returns is the variance of monthly market-adjusted stock returns over the 60 months preceding $t$.
- $Risk_{i,t}$ (Sloan, 1993): the ranked ratio of risk in earnings to risk in returns. First, the market model is estimated over the five years prior to $t$, with annual raw returns (equally-weighted market returns) cumulated over 12 months as the dependent (independent) variable. Risk in returns is the variance of the market model slope times the equally weighted market index, computed over the 60 months prior to $t$. Earnings risk is estimated as follows. First, earnings are regressed on the residuals from the market model over the five years prior to $t$. This regression's residuals are scaled by its slope, and the variance of the scaled residuals is calculated over the five years prior to $t$.
- $Risk_{i,t}$ (Standard deviation of earnings): the ranked standard deviation of earnings $A_{i,t}$ over the five years prior to $t$.

- $Own_{i,t}$: natural logarithm of the percentage of company stock owned by the CEO of firm $i$ in $t$, which is the ratio the number of shares owned by the CEO excluding options (EXECUCOMP: SHROWN) to the number of shares outstanding of the firm (EXECUCOMP: SHRSOUT).

- $r_{i,t-\tau}$: real annual market-adjusted returns for firm $i$ in fiscal $t-\tau$, computed by cumulating monthly market-adjusted returns for $t-\tau$. The market is the equally-weighted index, and returns are inclusive of dividends and adjusted for stock splits, with $\tau$ equal to 0, 1, 2, or 3.

- $||r_{i,t-\tau}||$: ranked absolute value of real annual market-adjusted returns for firm $i$ in fiscal $t-\tau$. Returns are cumulated monthly market-adjusted returns for $t-\tau$, where the market is the equally-weighted index. Returns are inclusive of dividends and adjusted for stock splits, with $\tau$ equal to 1, 2, or 3.

- $Vol_{i,t}$: standard deviation of monthly raw returns, computed over the 60 months prior to $t$.

- $Size_{i,t}$: natural logarithm of sales (COMPUSTAT #12) at the end of $t-1$.

- $Tenure_{i,t}$: natural logarithm of the number of years between the time the CEO of firm $i$ is appointed, and the sample year $t$.

- $Threshold_{A_{i,t}}$: a dummy that equals 1 if earnings $A_{i,t}$ are larger than 80% of $t-1$ earnings $A_{i,t-1}$, and 0 otherwise

- $\psi_i$: earnings persistence, estimated between 1983 and 2004 for each firm $i$, from the following IMA(1,1) process, as in Baber et al. (1998): $A_t - A_{t-1} = UA_t - \Psi UA_{t-1}$, where $UA_{i,t}$ is the earnings innovation. If $\Psi = 0$, earnings follow a random walk and all earnings innovations are permanent; if $\Psi = 1$, earnings follow a mean reverting process and all earnings innovations are transitory. Following Baber et al. (1998), $\psi = 1 - \Psi$ captures the extent to which earnings innovations are permanent versus transitory and thus measures earnings persistence. Table G.2 shows that the average (median) earnings persistence $\psi$ is 0.71 (0.69), which compares to the average (median) earnings persistence of 0.86 (0.85) documented in Baber et al. (1998).

# Appendix E

# Control variables for the sensitivity of CEO cash pay to earnings

This appendix explains the economic rationale for the choice of the control variables $CV$ for the sensitivity of CEO cash pay to earnings. Appendix D further details the computation of these variables.

- **Risk in earnings** $Risk_{i,t}$. The weight on earnings is affected by the extent to which earnings noise introduces risk into CEO cash pay (Lambert and Larcker, 1987). When earnings are less risky compared to returns, the weight on earnings relative to the weight on returns increases.

- **Growth options** $B/M_{i,t}$. Investment opportunities affect the weight on earnings in two offsetting ways (Smith and Watts, 1992). On one hand, because CEO actions of firms with many growth options are less readily observable, such firms are likely to have incentive plans, such as earnings-based bonus plans. On the other hand, to the extent that earnings are less informative about CEO actions when there are substantial growth options, the weight on earnings declines as growth options increase.

- **Earnings persistence** $\psi_i$. More persistent earnings receive a larger weight to mitigate the horizon problem, which arises because the CEO's tenure is shorter than the firm's investment horizon (Baber et al., 1998). Contracts that reward CEOs for persistent earnings encourage them to look beyond current earnings, and thus extend their decision horizon.

- **CEO tenure** $Tenure_{i,t}$. CEOs with longer tenure are closer to retirement and have less implicit incentives from career concerns. Instead, they receive larger explicit incentives in the form of pay-for-performance (Gibbons and Murphy, 1992; Baber et al., 1998).

- **CEO ownership** $Own_{i,t}$. CEO stockholdings influence the weight on earnings in two offsetting ways (Sloan, 1993). First, since large stockholdings provide strong incentives, CEOs with high stockholdings receive less of other types of incentive pay, including earnings-based incentives. Second, large stockholdings increase the CEO's exposure to noise in returns. To limit the sensitivity of CEO wealth to such noise, the weight on earnings rises with CEO stockholdings.

# Appendix F

# Control variables for the level of CEO cash pay

This appendix explains the economic rationale for the choice of the control variables $K$ for the level of CEO cash pay. Appendix D further details the computation of these variables.

- **Firm size** $Size_{i,t}$. Larger firms may hire better-qualified and better-paid managers (Murphy, 1999), and hence pay more.

- **Growth options** $B/M_{i,t}$. Firms with more growth options pay larger salaries, since CEOs are uniquely qualified to make investment decisions and good CEOs are scarce (Smith and Watts, 1992). The relation between growth options and the level of bonus pay is ambiguous (Smith and Watts, 1992). One one hand, because CEO actions are less readily observable for firms with substantial growth options, such firms are more likely to tie CEO pay to performance, and to have bonus plans. On the other hand, because earnings are less informative about CEO actions for firms with many growth options, such firms are less likely to have earnings-based performance plans, such as bonus plans.

- **Firm risk** $Vol_{i,t}$. Agency theory does not make an unambiguous prediction about the relation between the level of CEO pay and firm risk (Aggarwal and Samwick, 1999). Hence no prediction is made.

- **The number of board meetings** $Meet_{i,t}$. The number of board meetings captures differences in corporate governance. Firms with more board meetings likely monitor their CEO more closely, which results in lower agency problems (Hermalin and Weisbach, 2001) and lower CEO pay.

- **CEO ownership** $Own_{i,t}$. CEOs who own a larger percentage of the firm earn less cash pay (Core et al., 1999) , which is consistent with evidence in Ang et al. (2000) that agency costs are lower when managers own equity than when they do not own equity.

- **CEO tenure** $Tenure_{i,t}$. CEO tenure captures the CEO's firm-specific business experience. CEOs with more years of experience in the firm tend to be paid more (Deckop, 1988).

- **Interlocked CEOs** $Interlock_{i,t}$. CEOs are interlocked if they are either on the compensation committee of their firm, or serve on the board of a company managed by an executive who is on the board of their own firm. Such interlocked CEOs may be more entrenched and receive larger CEO pay (Hallock, 1997).

- **CEO chairman** $Chair_{i,t}$. CEOs who are chairmen of the board of directors earn higher cash pay (Core et al., 1999), possibly because the chairman title is a reward for CEOs with good past performance (Brickley et al., 1997). Vancil (1987) argues that firms use the chairman title as an incentive. CEOs only become chairman after a probation period, during which they are monitored by the board, and the chairman title is held by the former CEO.

# Appendix G

# Tables

Table G.1: Sample selection, 1992-2004

| | Firms | Firm-years |
|---|---|---|
| Data on CEO compensation from EXECUCOMP, 1992 - 2004 | 2,452 | 21,877 |
| CEO serves partial year | (35) | (4,891) |
| | 2,417 | 16,986 |
| CEO has less than 2 years of tenure | (65) | (2,003) |
| | 2,352 | 14,983 |
| Multiple CEOs by firm and year | (10) | (170) |
| | 2,342 | 14,813 |
| Multiple firms by CEO and year | (7) | (96) |
| | 2,335 | 14,717 |
| No data on earnings before extraordinary items, and discontinued operations, COMPUSTAT #18 | (2) | (17) |
| | 2,333 | 14,700 |
| Less then 24 months of return data on CRSP | (15) | (129) |
| | 2,318 | 14,571 |
| Firm-years with fiscal year changes | (0) | (13) |
| | 2,318 | 14,558 |
| Annualized return data not available by fiscal year | (3) | (95) |
| Final sample | 2,315 | 14,463 |

Table G.2: Descriptive statistics

| | Mean | St.Dev. | Percentile 25th | 50th | 75th | # |
|---|---|---|---|---|---|---|
| **CEO Pay** | | | | | | |
| Salary | 497 | 269 | 312 | 450 | 635 | 14,126 |
| Bonus | 529 | 1,334 | 64 | 263 | 590 | 14,126 |
| Cash Pay | 1,025 | 1,431 | 449 | 726 | 1198 | 14,126 |
| Total Pay | 3,327 | 9,555 | 784 | 1,539 | 3,295 | 13,838 |
| $\frac{Bonus}{CashPay}$ | 0.36 | 0.24 | 0.17 | 0.39 | 0.53 | 14,105 |
| $\frac{CashPay}{TotalPay}$ | 0.55 | 0.28 | 0.32 | 0.53 | 0.79 | 13,838 |
| **Unranked estimation risk proxies** | | | | | | |
| Analysts' forecast dispersion in $t-1$, $Disp'_{i,t-1}$ | 0.28 | 0.06 | 0.03 | 0.06 | 0.14 | 19,114 |
| Absolute value of returns in $t-1$, $\|\|r'_{i,t-1}\|\|$ | 0.32 | 0.35 | 0.10 | 0.23 | 0.43 | 14,443 |
| Absolute value of returns in $t-2$, $\|\|r'_{i,t-2}\|\|$ | 0.32 | 0.35 | 0.02 | 0.22 | 0.42 | 14,443 |
| Absolute value of returns in $t-3$, $\|\|r'_{i,t-3}\|\|$ | 0.30 | 0.35 | 0.21 | 0.08 | 0.21 | 14,443 |
| **Firm Characteristics** | | | | | | |
| Earnings, $A_{i,t}$ | 4.3% | 6.0% | 1.6% | 5.0% | 9.8% | 14,459 |
| Returns in $t$, $r_{i,t}$ | 3.5% | 47% | -22.3% | 0.0% | 24.1% | 14,463 |
| Returns in $t-1$, $r_{i,t-1}$ | 6.8% | 47% | -19.4% | 2.1% | 26.9% | 14,463 |
| Returns in $t-2$, $r_{i,t-2}$ | 8.7% | 46% | -16.1% | 3.1% | 28.3% | 14,463 |
| Returns in $t-3$, $r_{i,t-3}$ | 8.2% | 45% | -15.4% | 1.4% | 27.8% | 14,463 |
| Size, $Sales_{i,t-1}$ | 3,577 | 10,182 | 323 | 904 | 2,789 | 14,453 |
| Growth options, $B/M_{i,t}$ | 0.71 | 0.29 | 0.49 | 0.73 | 0.92 | 14,186 |
| Firm risk, $Vol_{i,t}$ | 0.12 | 0.06 | 0.08 | 0.11 | 0.15 | 14,268 |
| Earnings persistence, $\psi_i$ | 0.70 | 0.52 | 0.38 | 0.68 | 1.07 | 14,458 |
| Earnings risk, $Risk_{i,t}$ | 0.49 | 0.29 | 0.24 | 0.49 | 0.74 | 13,891 |
| # of board meetings, $Meet_{i,t}$ | 7.1 | 2.9 | 5.00 | 6.00 | 7.00 | 13,810 |
| **CEO characteristics** | | | | | | |
| CEO Ownership, $OWN_{i,t}$ | 3.2% | 6.9% | 0.1% | 0.5% | 2.2% | 14,113 |
| CEO Tenure, $Tenure_{i,t}$, years | 9.2 | 7.4 | 4.00 | 6.9 | 11.9 | 14,463 |
| CEO is chairman | | | 65.1% | | | 14,463 |
| CEO is interlocked | | | 9.3% | | | 14,463 |

This table displays selected statistics for the 2,315 sample firms between 1992 and 2004. "Cash Pay" is the sum of bonus and salary. "Total Pay" includes cash pay, other annual pay (such as gross-ups for tax liabilities, perquisites, preferential discounts on stock purchases), long-term incentives payouts, all other compensation (such as payouts for cancellation of stock options, 401K contributions, signing bonuses, tax reimbursements), the value of restricted stock granted during the year, determined at grant date, and the value of stock option grants, estimated using Black-Scholes. All CEO pay data is in thousands of 1992 U.S. dollars. "CEO is chairman" shows instances where the CEO is chairman of the board of directors. "CEO is interlocked" shows instances where the CEO is in an interlocking relationship. The estimation risk proxies shown, $Disp'_{i,t-1}$ and $||r'_{i,t-\tau}||$, are not ranked (unlike the estimation risk proxies, $Disp_{i,t-1}$ and $||r_{i,t-\tau}||$, used in the rest of the thesis, which are ranked). $Disp'_{i,t-1}$ is the standard deviation of analysts' forecasts made during fiscal year $t-1$ for earnings in fiscal year $t$, scaled by average absolute forecasts made during $t-1$ for earnings in $t$. $||r'_{i,t-\tau}||$ is the absolute value of returns in $t-\tau$, with $\tau$ equal to 1, 2 or 3. All other variables are defined as in Appendix D.

Table G.3: Pearson correlation coefficients for selected explanatory variables

| | $A_{i,t}$ | $\|\|r_{i,t-1}\|\|$ | $\|\|r_{i,t-2}\|\|$ | $\|\|r_{i,t-3}\|\|$ | $Disp_{i,t-1}$ |
|---|---|---|---|---|---|
| $A_{i,t}$ | | $-0.02^a$ | $-0.04^a$ | $-0.03^a$ | $-0.20^a$ |
| $\|\|r_{i,t-1}\|\|$ | | | $0.22^a$ | $0.13^a$ | $0.16^a$ |
| $\|\|r_{i,t-2}\|\|$ | | | | $0.21^a$ | $0.14^c$ |
| $\|\|r_{i,t-3}\|\|$ | | | | | $0.13^a$ |
| $Size_{i,t}$ | $0.09^a$ | $-0.19^a$ | $-0.18^a$ | $-0.12^a$ | $-0.16^a$ |
| $B/M_{i,t}$ | $-0.21^a$ | $-0.10^a$ | $-0.11^a$ | $-0.05^a$ | $0.20^a$ |
| $Vol_{i,t}$ | $-0.16^a$ | $0.35^a$ | $0.37^a$ | $0.32^a$ | $0.37^a$ |
| $Risk_{i,t}$ | $-0.02^b$ | $0.05^a$ | $0.04^a$ | 0.04 | $0.32^a$ |
| $\psi_i$ | $0.08^a$ | $0.04^a$ | $0.03^a$ | $0.04^a$ | $-0.03^a$ |
| $Meet_{i,t}$ | $-0.09^a$ | $-0.01$ | $-0.02^b$ | $-0.01$ | $0.02^b$ |
| $r_{i,t}$ | $0.18^a$ | $0.09^a$ | $0.04^a$ | $-0.01$ | $0.06^a$ |
| $r_{i,t-1}$ | $0.09^a$ | $0.23^a$ | $0.09^a$ | $0.02^c$ | $-0.11^a$ |
| $r_{i,t-2}$ | $0.02^a$ | $0.07^a$ | $0.26^a$ | $0.06^a$ | $-0.07$ |
| $r_{i,t-3}$ | $0.02^c$ | $0.06^a$ | $0.06^a$ | $0.26^a$ | $-0.01$ |
| $Own_{i,t}$ | $0.07^a$ | $0.13^a$ | $0.11^a$ | $0.07^a$ | $-0.02^b$ |
| $Tenure_{i,t}$ | $0.04^a$ | $0.02^b$ | $0.02^c$ | $0.05^a$ | $-0.08^a$ |
| $Chair_{i,t}$ | -0.01 | $-0.08^a$ | $-0.08^a$ | $-0.03^a$ | $-0.10^a$ |
| $Interlock_{i,t}$ | $0.03^a$ | $-0.01$ | $-0.01$ | $-0.01$ | $-0.01^a$ |

This table presents the Pearson correlation coefficients for the 2,315 firms and 14,463 firm-years between 1992 and 2004. $A_{i,t}$ are earnings (COMPUSTAT #18) scaled by beginning-of-year total assets (COMPUSTAT #6). $||r_{i,t-\tau}||$ is the ranked absolute value of returns in $t-\tau$, with $\tau$ equal to 1, 2 or 3. $Disp_{i,t-1}$ is the ranked standard deviation of analysts forecasts made during $t-1$ for earnings in $t$, scaled by the absolute average forecast made in $t-1$ for earnings in $t$. All other variables are defined as in Appendix D. $^a$ ($^b$) [$^c$] denotes significance at the 1% (5%) [10%] level.

Table G.4: The effect of estimation risk on the relation between CEO cash pay and earnings. Estimation risk proxy: Analysts' forecast dispersion in $t-1$, $Disp_{i,t-1}$

$$C_{i,t} = a_0 + b_0 A_{i,t} + \mathbf{b_1 A_{i,t} Disp_{i,t-1}} + c_1 Disp_{i,t-1} + g_1 A_{i,t} B/M_{i,t} + g_2 A_{i,t} Risk_{i,t} + g_3 A_{i,t}\psi_i + g_4 A_{i,t} Own_{i,t} + g_5 A_{i,t} Tenure_{i,t} + h_0 r_{i,t} + h_\tau r_{i,t-\tau} + \Gamma K + \varepsilon_{i,t}$$

| Coefficient | Independent Variable | Predicted Sign | Estimated value Cash Pay (1) | Estimated value Bonus Pay (2) |
|---|---|---|---|---|
| $b_0$ | $A_{i,t}$ | + | 0.948*** | 7.728*** |
| | | | (3.07) | (4.63) |
| $\mathbf{b_1}$ | $\mathbf{A_{i,t}Disp_{i,t-1}}$ | **-** | **-0.460*** ** | **-2.790*** ** |
| | | | **(-3.19)** | **(-3.53)** |
| $c_1$ | $Disp_{i,t-1}$ | ? | 0.033* | 0.319*** |
| | | | (1.74) | (2.73) |
| $g_1$ | $A_{i,t}B/M_{i,t}$ | ? | 0.432*** | 3.053*** |
| | | | (4.66) | (4.22) |
| $g_2$ | $A_{i,t}Risk_{i,t}$ | - | -1.040*** | -7.430*** |
| | | | (-6.04) | (-7.26) |
| $g_3$ | $A_{i,t}\psi_i$ | + | 0.443*** | 2.480*** |
| | | | (4.47) | (4.45) |
| $g_4$ | $A_{i,t}Own_{i,t}$ | ? | -0.032* | -0.245** |
| | | | (-1.68) | (-2.13) |
| $g_5$ | $A_{i,t}Tenure_{i,t}$ | + | 0.017 | -0.570 |
| | | | (0.21) | (-1.38) |
| $h_0$ | $r_{i,t}$ | + | 0.199*** | 1.118*** |
| | | | (17.46) | (14.84) |
| $h_1$ | $r_{i,t-1}$ | ? | 0.155*** | 0.779*** |
| | | | (13.71) | (11.78) |
| $h_2$ | $r_{i,t-2}$ | ? | 0.053*** | 0.258*** |
| | | | (5.79) | (4.70) |
| $h_3$ | $r_{i,t-3}$ | ? | 0.035*** | 0.125** |
| | | | (3.86) | (2.36) |
| Adjusted $R^2$ | | | 23.1% | 13.9% |
| # of observations | | | 10,873 | 10,891 |

$C_{i,t}$ is either the natural logarithm of CEO cash pay (the sum of salary and bonus pay), in column (1), or the natural logarithm of CEO bonus pay (when bonus pay is \$0, the natural logarithm of \$1 is used), in column (2), for firm $i$ in year $t$. $A_{i,t}$ is earnings, defined as income before extraordinary items and discontinued operations (COMPUSTAT #18) divided by prior-year total assets (COMPUSTAT #6). $Disp_{i,t-1}$ is the ranked standard deviation of analysts forecasts made during $t-1$ for earnings in $t$, scaled by the absolute average forecast made in $t-1$ for earnings in $t$. All variables are described in Appendix D. The regression is estimated from 1992 to 2004 in the pooled cross-section using fixed effects estimation, with effects for CEOs and fiscal years. To keep the size of the table manageable, only the relevant variables are displayed. $t$-statistics (in parentheses) are computed with standard errors adjusted for heteroscedasticity using the White correction.

Table G.5: The effect of estimation risk on the relation between CEO cash pay and earnings. Estimation risk proxy: Absolute value of past returns, $||r_{i,t-\tau}||$

$$C_{i,t} = a_0 + b_0 A_{i,t} + \mathbf{b_\tau A_{i,t}||r_{i,t-\tau}||} + c_\tau ||r_{i,t-\tau}|| + g_1 A_{i,t} B/M_{i,t} + g_2 A_{i,t} Risk_{i,t} + g_3 A_{i,t}\psi_i + g_4 A_{i,t} Own_{i,t} + g_5 A_{i,t} Tenure_{i,t} + h_0 r_{i,t} + h_\tau r_{i,t-\tau} + \Gamma K + \varepsilon_{i,t}$$

| Coefficient | Independent Variable | Predicted Sign | Estimated value (1) | (2) | (3) | Coefficient | Independent Variable | Predicted Sign | Estimated value (4) | (5) | (6) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $b_0$ | $A_{i,t}$ | + | 0.976*** | 1.122*** | 1.265*** | $g_1$ | $A_{i,t}B/M_{i,t}$ | ? | 0.112* | -0.032 | -0.37 |
| | | | (3.90) | (4.68) | (4.81) | | | | (1.69) | (-0.38) | (-0.66) |
| $\mathbf{b_1}$ | $\mathbf{A_{i,t}\|\|r_{i,t-1}\|\|}$ | - | -0.592*** | -0.584*** | -0.593*** | $g_2$ | $A_{i,t}Risk_{i,t}$ | - | -1.010*** | -1.020*** | -1.030*** |
| | | | (-5.74) | (-5.88) | (-6.00) | | | | (-6.25) | (-6.35) | (-6.45) |
| $\mathbf{b_2}$ | $\mathbf{A_{i,t}\|\|r_{i,t-2}\|\|}$ | - | | -0.413*** | -0.413*** | $g_3$ | $A_{i,t}\psi_i$ | + | 0.355*** | 0.334*** | 0.328*** |
| | | | | (-4.06) | (-4.03) | | | | (3.66) | (3.49) | (3.44) |
| $\mathbf{b_3}$ | $\mathbf{A_{i,t}\|\|r_{i,t-3}\|\|}$ | - | | | -0.051 | $g_4$ | $A_{i,t}Own_{i,t}$ | ? | -0.016 | -0.027 | -0.027 |
| | | | | | (-0.55) | | | | (-0.89) | (-1.42) | (-1.43) |
| $c_1$ | $\|\|r_{i,t-1}\|\|$ | ? | 0.024* | 0.026** | 0.030** | $g_5$ | $A_{i,t}Tenure_{i,t}$ | + | 0.174** | 0.201*** | 0.205*** |
| | | | (1.94) | (2.11) | (2.45) | | | | (2.51) | (2.95) | (3.01) |
| $c_2$ | $\|\|r_{i,t-2}\|\|$ | ? | | 0.045*** | 0.049*** | $h_0$ | $r_{i,t}$ | + | 0.186*** | 0.187*** | 0.188*** |
| | | | | (3.55) | (3.84) | | | | (18.76) | (18.93) | (18.76) |
| $c_3$ | $\|\|r_{i,t-3}\|\|$ | ? | | | 0.036*** | $h_1$ | $r_{i,t-1}$ | ? | 0.153*** | 0.152*** | 0.151*** |
| | | | | | (2.85) | | | | (13.90) | (13.83) | (13.86) |
| $p$-value for $b_1 = b_2$ | | | | 0.189 | 0.169 | $h_2$ | $r_{i,t-2}$ | ? | 0.244*** | 0.243*** | 0.238*** |
| $p$-value for $b_2 = b_3$ | | | | | 0.014 | | | | (4.95) | (4.91) | (4.81) |
| $p$-value for $b_1 = b_3$ | | | | | $< 0.01$ | $h_3$ | $r_{i,t-3}$ | ? | 0.035*** | 0.035*** | 0.031*** |
| Adjusted $R^2$ | | | 21.9% | 22.2% | 22.3% | | | | (4.27) | (4.23) | (3.66) |
| # of observations | | | 12,523 | 12,523 | 12,523 | | | | | | |

$C_{i,t}$ is the natural logarithm of CEO cash pay (the sum of salary and bonus pay) for firm $i$ in year $t$. $A_{i,t}$ is earnings, defined as income before extraordinary items and discontinued operations (COMPUSTAT #18) divided by prior-year total assets (COMPUSTAT #6). $||r_{i,t-\tau}||$ is the ranked absolute value of market-adjusted returns in $t-\tau$, with $\tau$ equal to 1, 2, or 3. All variables are described in Appendix D. The regression is estimated from 1992 to 2004 in the pooled cross-section using fixed effects estimation, with effects for CEOs and fiscal years. To keep the size of the table manageable, only the relevant variables are displayed. $t$-statistics (in parentheses) are computed with standard errors adjusted for heteroscedasticity using the White correction.

Table G.6: The effect of estimation risk on the relation between CEO bonus pay and earnings. Estimation risk proxy: Absolute value of past returns, $||r_{i,t-\tau}||$

$$C_{i,t} = a_0 + b_0 A_{i,t} + \mathbf{b}_\tau \mathbf{A}_{\mathbf{i,t}} ||\mathbf{r}_{\mathbf{i,t}-\tau}|| + c_\tau ||r_{i,t-\tau}|| + g_1 A_{i,t} B/M_{i,t} + g_2 A_{i,t} Risk_{i,t}$$
$$+ g_3 A_{i,t} \psi_i + g_4 A_{i,t} Own_{i,t} + g_5 A_{i,t} Tenure_{i,t} + h_0 r_{i,t} + h_\tau r_{i,t-\tau} + \Gamma K + \varepsilon_{i,t}$$

| Coefficient | Independent Variable | Predicted Sign | Estimated value (1) | (2) | (3) | Coefficient | Independent Variable | Predicted Sign | Estimated value (4) | (5) | (6) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $b_0$ | $A_{i,t}$ | + | 6.799*** | 7.521*** | 7.989*** | $g_1$ | $A_{i,t} B/M_{i,t}$ | ? | 1.525*** | 1.091* | 1.028* |
| | | | (5.08) | (5.44) | (5.60) | | | | (2.81) | (1.87) | (1.74) |
| **$\mathbf{b_1}$** | **$\mathbf{A_{i,t}} \|\|\mathbf{r_{i,t-1}}\|\|$** | - | **-3.66*** ** | **-3.720*** ** | **-3.570*** ** | $g_2$ | $A_{i,t} Risk_{i,t}$ | - | -6.620*** | -6.660*** | -6.770*** |
| | | | **(-6.22)** | **(-6.23)** | **(-6.44)** | | | | (-7.53) | (-7.57) | (-7.68) |
| **$\mathbf{b_2}$** | **$\mathbf{A_{i,t}} \|\|\mathbf{r_{i,t-2}}\|\|$** | - | | **-1.230** ** | **-1.200*** ** | $g_3$ | $A_{i,t} \psi_i$ | + | 1.983*** | 1.932*** | 1.887*** |
| | | | | **(-2.59)** | **(-2.55)** | | | | (4.16) | (4.01) | (3.93) |
| **$\mathbf{b_3}$** | **$\mathbf{A_{i,t}} \|\|\mathbf{r_{i,t-3}}\|\|$** | - | | | **-0.663** | $g_4$ | $A_{i,t} Own_{i,t}$ | ? | -0.209** | -0.241** | -0.244** |
| | | | | | **(-1.41)** | | | | (-2.01) | (-2.26) | (-2.32) |
| $c_1$ | $\|\|r_{i,t-1}\|\|$ | ? | 0.104 | 0.101 | 0.125* | $g_5$ | $A_{i,t} Tenure_{i,t}$ | + | 0.470 | 0.554* | 0.596* |
| | | | (1.39) | (1.35) | (1.65) | | | | (1.41) | (1.66) | (1.78) |
| $c_2$ | $\|\|r_{i,t-2}\|\|$ | ? | | 0.078 | 0.099 | $h_0$ | $r_{i,t}$ | + | 1.065*** | 1.070*** | 1.071*** |
| | | | | (1.04) | (1.29) | | | | (16.64) | (16.69) | (16.55) |
| $c_3$ | $\|\|r_{i,t-3}\|\|$ | ? | | | 0.193*** | $h_1$ | $r_{i,t-1}$ | ? | 0.750*** | 0.748*** | 0.749*** |
| | | | | | (2.53) | | | | (12.52) | (12.52) | (12.59) |
| $p$-value for $b_1 = b_2$ | | | | < 0.01 | < 0.01 | $h_2$ | $r_{i,t-2}$ | ? | 0.244*** | 0.243*** | 0.238*** |
| $p$-value for $b_2 = b_3$ | | | | | 0.409 | | | | (4.95) | (4.91) | (4.81) |
| $p$-value for $b_1 = b_3$ | | | | | < 0.01 | $h_3$ | $r_{i,t-3}$ | ? | 0.152*** | 0.151*** | 0.130*** |
| Adjusted $R^2$ | | | 13.6% | 13.7% | 13.8% | | | | (3.24) | (3.22) | (2.71) |
| # of observations | | | 12,541 | 12,526 | 12,526 | | | | | | |

$C_{i,t}$ is the natural logarithm of CEO bonus pay awarded by firm $i$ in year $t$ (when bonus pay is $0, the natural logarithm of $1 is used). $A_{i,t}$ is earnings, defined as income before extraordinary items and discontinued operations (COMPUSTAT #18) divided by prior-year total assets (COMPUSTAT #6). $||r_{i,t-\tau}||$ is the absolute value of market-adjusted stock returns in year $t-\tau$ (with $\tau$ equal to 1, 2, or 3) ranked across all observations in $t-\tau$. All variables are described in Appendix D. The regression is estimated from 1992 to 2004 in the pooled cross-section using fixed effects estimation, with effects for CEOs and fiscal years. To keep the size of the table manageable, only the relevant variables are displayed. $t$-statistics (in parentheses) are computed with standard errors adjusted for heteroscedasticity using the White correction.

Table G.7: Time and industry profile for the 196 experimental firms

Panel A. Time profile

| Year | Number of firms | Percentage |
|---|---|---|
| 1993 | 8 | 4.1 |
| 1994 | 6 | 3.1 |
| 1995 | 13 | 6.6 |
| 1996 | 10 | 5.1 |
| 1997 | 13 | 6.6 |
| 1998 | 29 | 14.8 |
| 1999 | 27 | 13.8 |
| 2000 | 42 | 21.4 |
| 2001 | 20 | 10.2 |
| 2002 | 25 | 12.8 |
| 2003 | 3 | 1.5 |

Panel B. Industry profile

| SIC code | Description | Number of firms | Percentage | Percentage COMPUSTAT |
|---|---|---|---|---|
| 10 | Metal & Mining | 1 | 0.5 | 1.4 |
| 13 | Oil & Gas Extraction | 2 | 1.0 | 0.3 |
| 20 | Food | 1 | 0.5 | 1.9 |
| 23 | Apparel | 3 | 1.5 | 0.8 |
| 24 | Lumber & Wood | 2 | 1.0 | 0.4 |
| 25 | Furniture | 2 | 1.0 | 0.4 |
| 27 | Printing & Publishing | 1 | 0.5 | 1.1 |
| 28 | Chemicals | 27 | 13.7 | 6.6 |
| 30 | Rubber | 1 | 0.5 | 0.9 |
| 33 | Primary Metal Industry | 5 | 2.5 | 1.2 |
| 35 | Industrial & Commercial Machinery | 19 | 9.7 | 5.2 |
| 36 | Electronics | 56 | 28.4 | 6.4 |
| 37 | Transportation | 3 | 1.5 | 1.8 |
| 38 | Measuring & Controlling Instruments | 8 | 4.1 | 5.2 |
| 45 | Air Transport | 1 | 0.5 | 0.6 |
| 48 | Communication | 1 | 0.5 | 3.9 |
| 49 | Electric, Gas & Sanitary Services | 2 | 1.0 | 4.0 |
| 50 | Wholesale Trade - Durables | 2 | 1.0 | 2.1 |
| 54 | Food Stores | 1 | 0.5 | 0.6 |
| 57 | Home Furniture | 1 | 0.5 | 0.4 |
| 58 | Restaurants | 2 | 1.0 | 1.4 |
| 59 | Miscellaneous Retail | 2 | 1.0 | 1.7 |
| 60 | Depository Institutions | 1 | 0.5 | 8.8 |
| 62 | Security & Commodity Brokers | 1 | 0.5 | 1.1 |
| 63 | Insurance Carriers | 3 | 1.5 | 2.4 |
| 64 | Insurance Agents | 1 | 0.5 | 0.4 |
| 67 | Holding Offices and other | 2 | 1.0 | 3.5 |
| 73 | Business Services | 41 | 20.8 | 11.6 |
| 80 | Health Services | 5 | 2.5 | 1.6 |

This table presents the time and industry profile for the 196 experimental firms, between 1993 and 2003. Experimental firms are subject to the most extreme shocks in $t-1$. "Percentage COMPUSTAT" indicates the percentage of COMPUSTAT firm-years that are in a given 2-digit SIC industry between 1993 and 2003.

Table G.8: Descriptive statistics for the matched sample, in the year $t$ following the economic shock in $t-1$

| | Mean | | Difference | Median | | Difference |
|---|---|---|---|---|---|---|
| | Experimentals | Controls | $p$-value | Experimentals | Controls | $p$-value |
| **CEO pay** | | | | | | |
| Salary | 372 | 412 | 0.02 | 320 | 384 | <0.01 |
| Bonus | 218 | 369 | 0.03 | 89 | 176 | <0.01 |
| Cash Pay | 591 | 782 | 0.01 | 424 | 548 | <0.01 |
| Restricted Stock | 245 | 76 | 0.23 | 0 | 0 | 0.56 |
| Stock Options | 1,947 | 1,996 | 0.70 | 753 | 428 | 0.20 |
| Total Pay | 2,854 | 2,923 | 0.99 | 1,572 | 1,440 | 0.46 |
| $\frac{Bonus}{CashPay}$ | 0.25 | 0.33 | <0.01 | 0.23 | 0.36 | <0.01 |
| $\frac{EquitybasedPay}{TotalPay}$ | 0.50 | 0.42 | 0.05 | 0.59 | 0.41 | 0.03 |
| **CEO Characteristics** | | | | | | |
| CEO Ownership | 5.5% | 3.3% | 0.01 | 1.1% | 0.5% | <0.01 |
| CEO Tenure (years) | 9.1 | 7.9 | 0.18 | 7.7 | 6.1 | 0.04 |
| CEO is chairman | 44.7% | 48.2% | | | | |
| CEO is interlocked | 11.5% | 4.7% | | | | |
| **Firm Characteristics** | | | | | | |
| Book-to-Market Ratio | 0.59 | 0.72 | <0.01 | 0.51 | 0.70 | <0.01 |
| Volatility, prior 5 years | 0.18 | 0.14 | <0.01 | 0.17 | 0.13 | <0.01 |
| Sales | 1,301 | 2,132 | <0.01 | 336 | 508 | <0.01 |

This table presents descriptive statistics for the 196 experimental firms ("Experimentals") and the 196 control firms ("Controls"), between 1993 and 2003. Experimental firms are subject to the most extreme shocks in $t-1$, while control firms experience the least extreme shocks in $t-1$. Control firms are matched to experimental firms based on the market value of equity in $t-2$ and the 2-digit SIC code in $t-2$. The column "Difference" tests the difference between experimental and control firms. It shows the $p$-value for the $t$-test (Wilcoxon signed rank test) of the difference in means (medians).

"Cash Pay" is bonus and salary. "Restricted Stock" is the value of restricted stock granted during the year, determined at grant date. "Stock Options" is the value of stock option grants, estimated using Black-Scholes. "Total Pay" includes cash pay, other annual pay (such as gross-ups for tax liabilities, perquisites, preferential discounts on stock purchases), long-term incentives payouts, all other compensation (such as payouts for cancellation of stock options, 401K contributions, signing bonuses, tax reimbursements), restricted stock and stock options. Equity-based Pay is the sum of restricted stock and stock options. All CEO pay data is in thousands of 1992 U.S. dollars. "CEO ownership" is the percentage of the company stock owned by the CEO (excluding stock options). "CEO Tenure" is the number of years between the time the CEO is appointed and the sample year. "CEO is chairman" shows instances where the CEO is chairman of the board of directors. "CEO is interlocked" shows instances where the CEO is in an interlocking relationship. "Book-to-Market Ratio" is book value of the firm's assets in $t$ divided by the market value of the firm in $t$. The market value of the firm is the price per share at year end times the number of shares outstanding. "Volatility" is the standard deviation of stock returns over the 60 months prior to $t$. "Sales" (in million U.S. dollars) is COMPUSTAT #12 in $t$.

Table G.9: Criteria used to identify subjective and objective non-financial performance measures

| Panel A. Subjective performance measures |
|---|
| - explicit mention of "subjectivity" or "discretion" (or any variation of these words) |
| - explicit mention of "individual performance measures" or "individual performance evaluation" (or any variation of these words) |
| - performance measures explicitly specified ex post that have not been specified ex ante in the CEO bonus plan |
| **Panel B. Objective non-financial performance measures** |
| - Explicit reference to non-financial performance measures such as customer service, product quality, etc. |
| - Any financial performance measures, even if they are not based on earnings, such as cash flows or returns, do not qualify for non-financial performance measures |

This table presents the criteria used to identify subjective and objective non-financial performance measures in CEO bonus pay. The section describing CEO bonus plans in annual proxy statements is examined in $t-1$, the year of the economic shock, and in $t$, to identify subjective and objective non-financial performance measures used by the 196 experimental and the 196 control firms. Experimental firms are subject to the most extreme shocks in $t-1$, while control firms experience the least extreme shocks in $t-1$. Control firms are matched to experimental firms based on the market value of equity in $t-2$ and the 2-digit SIC code in $t-2$.

Table G.10: The frequency of subjective and objective non-financial performance measures

| | Performance measures | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Subjective | | | | | Objective non-financial | | | | |
| | Experimentals | | Controls | | $\chi^2$ | Experimentals | | Controls | | $\chi^2$ |
| | $t$ | $t-1$ | $t$ | $t-1$ | | $t$ | $t-1$ | $t$ | $t-1$ | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| **All performance measures** | **518** | **427** | **328** | **384** | **12.43***** | **76** | **67** | **37** | **35** | **0.06** |
| **Financial and Individual performance measures** | **206** | **177** | **158** | **185** | **4.32**** | | | | | |
| **1. Individual performance measures** | **51** | **52** | **35** | **35** | **0.00** | | | | | |
| **2. Financial performance measures** | **153** | **125** | **123** | **150** | **5.87**** | | | | | |
| - Sales | 26 | 21 | 11 | 32 | 8.20*** | | | | | |
| - Cost | 11 | 6 | 2 | 9 | 5.81** | | | | | |
| - Profit | 45 | 39 | 44 | 46 | 0.38 | | | | | |
| - Returns | 12 | 9 | 7 | 12 | 1.65 | | | | | |
| - Contribution to performance | 19 | 18 | 27 | 26 | 0.05 | | | | | |
| **Non-Financial performance measures** | **312** | **250** | **170** | **199** | **7.96***** | **76** | **67** | **37** | **35** | **0.06** |
| **1. Strategy** | **57** | **49** | **50** | **63** | **1.99** | **20** | **16** | **15** | **13** | 0.05 |
| - Strategic planning | 11 | 9 | 13 | 14 | 0.22 | 3 | 2 | 2 | 1 | 0.04 |
| - Alliance | 9 | 8 | 8 | 11 | 0.42 | 6 | 5 | 2 | 1 | 0.14 |
| - Marketing | 13 | 8 | 3 | 8 | 3.46* | 1 | 0 | 6 | 6 | 0.93 |
| **2. Innovation** | **63** | **47** | **27** | **26** | **0.58** | **12** | **12** | **0** | **3** | **2.70*** |
| - New Product Introduction & Development | 29 | 15 | 5 | 5 | 0.88 | 2 | 4 | 0 | 0 | - |
| - Research and Development | 23 | 26 | 12 | 9 | 0.61 | 7 | 4 | 0 | 3 | 3.82* |
| **3. Operations** | **48** | **37** | **24** | **26** | **0.91** | **14** | **13** | **3** | **4** | **0.06** |
| - Manufacturing | 14 | 8 | 1 | 1 | 0.15 | 3 | 1 | 1 | 1 | 0.38 |
| - Management | 21 | 15 | 15 | 14 | 0.65 | 6 | 5 | 2 | 2 | 0.02 |
| **4. Reorganization** | **24** | **20** | **14** | **19** | **1.11** | **3** | **3** | **0** | **1** | **0.88** |
| - M&A | 13 | 15 | 8 | 11 | 0.09 | 3 | 2 | 0 | 1 | 1.20 |
| - Divestiture | 8 | 4 | 1 | 1 | 0.21 | 0 | 0 | 0 | 0 | - |
| **5. CEO Qualities** | **20** | **18** | **16** | **9** | **0.80** | **0** | **0** | **0** | **0** | - |
| **6. Financing** | **20** | **10** | **2** | **2** | **0.43** | **5** | **2** | **3** | **3** | **0.63** |
| **7. Human Resources** | **18** | **13** | **10** | **14** | **1.46** | **2** | **3** | **6** | **6** | **0.14** |
| **8. Customers** | **15** | **13** | **6** | **12** | **1.81** | **10** | **10** | **7** | **4** | **0.53** |

This table presents the frequency with which various subjective and objective non-financial performance measures are reported in annual proxy statements by 196 experimental firms ("Experimentals") and 196 control firms ("Controls") between 1993 and 2003, in the year of the economic shock, $t-1$, and the year after, $t$. Experimental firms belong to the two percentiles of sample firms with the most extreme negative and the most extreme positive returns in $t-1$. Control firms belong to the two percentiles with the least extreme negative and the least extreme positive returns in $t-1$. Control firms are matched to experimental firms based on the market value in $t-2$ and the 2-digit SIC code in $t-2$. The $\chi^2$-test compares the number of times performance measures are reported by experimental and control firms in $t$ to the number of times performance measures are reported by experimental and control firms in $t-1$. *** (**) [*] denotes significance at the 1% (5%) [10%] level.

Table G.11: The average number of subjective and objective non-financial performance measures

Average number of subjective and objective non-financial performance measures used in the year of the economic shock, $t-1$, and the year after, $t$

| | Experimentals (1) | Controls (2) | Difference between Experimentals and Controls (3) |
|---|---|---|---|
| **A. All subjective performance measures** | | | |
| $t-1$ | 2.41 | 2.35 | |
| $t$ | 2.83 | 1.96 | |
| Difference between $t$ and $t-1$ | | | |
| Mean | 0.40 | -0.34 | 0.54 |
| $p$-value for $t$-stat | <0.01 | <0.01 | <0.01 |
| $p$-value for Signed Rank test | <0.01 | <0.01 | <0.01 |
| **A.1. Subjective financial and individual performance measures** | | | |
| $t-1$ | 0.92 | 0.94 | |
| $t$ | 1.06 | 0.81 | |
| Difference between $t$ and $t-1$ | | | |
| Mean | 0.14 | -0.14 | 0.25 |
| $p$-value for $t$-stat | <0.01 | <0.01 | 0.024 |
| $p$-value for Signed Rank test | <0.01 | <0.01 | 0.022 |
| **A.2. Subjective non-financial performance measures** | | | |
| $t-1$ | 1.29 | 1.01 | |
| $t$ | 1.60 | 0.87 | |
| Difference between $t$ and $t-1$ | | | |
| Mean | 0.31 | -0.14 | 0.27 |
| $p$-value for $t$-stat | <0.01 | 0.048 | 0.217 |
| $p$-value for Signed Rank test | <0.01 | <0.01 | 0.015 |
| **B. Objective non-financial performance measures** | | | |
| $t-1$ | 0.35 | 0.16 | |
| $t$ | 0.40 | 0.17 | |
| Difference between $t$ and $t-1$ | | | |
| Mean | 0.05 | 0.01 | -0.14 |
| $p$-value for $t$-stat | 0.180 | 0.528 | 0.336 |
| $p$-value for Signed Rank test | 0.227 | 0.754 | 0.625 |

Experimental firms ("Experimentals") belong to the two percentiles of sample firms with the most extreme negative and the most extreme positive returns in $t-1$. Control firms ("Controls") belong to the two percentiles with the least extreme negative and the least extreme positive returns in $t-1$. Control firms are matched to experimental firms based on the market value in $t-2$ and the 2-digit SIC code in $t-2$. The row "$p$-value for $t$-stat" ("$p$-value for Signed Rank test") tests the difference in performance measures between $t-1$ and $t$ based on the Student $t$-statistic (the Signed Rank test). Column (3), "Difference between Experimentals and Controls" shows the difference between experimental and control firms for the change in the various performance measures between $t-1$ and $t$, and is calculated using matched pairs.

Table G.12: The change in the number of subjective and objective non-financial performance measures

Number (#) and percentage (%) of firms that change the number of subjective and objective non-financial performance measures used between the year of the economic shock, $t-1$, and the year after, $t$

| | Experimentals | | Controls | | $\chi^2$ |
|---|---|---|---|---|---|
| | # | % | # | % | |
| | (1) | (2) | (3) | (4) | (5) |
| **A. All subjective performance measures** | | | | | |
| Increase | 42 | 21.4 | 8 | 4.1 | |
| Decrease | 10 | 5.1 | 29 | 14.8 | 33.12*** |
| Keep Constant | 144 | 73.5 | 159 | 81.1 | |
| **A.1. Subjective financial and individual performance measures** | | | | | |
| Increase | 26 | 13.3 | 9 | 4.6 | |
| Decrease | 5 | 2.6 | 19 | 9.7 | 16.45*** |
| Keep Constant | 165 | 84.1 | 168 | 85.7 | |
| **A.2. Subjective non-financial performance measures** | | | | | |
| Increase | 37 | 18.9 | 7 | 3.6 | |
| Decrease | 15 | 7.6 | 26 | 13.3 | 24.58*** |
| Keep Constant | 144 | 73.5 | 163 | 83.1 | |
| **B. Objective non-financial performance measures** | | | | | |
| Increase | 10 | 5.1 | 6 | 3.1 | |
| Decrease | 5 | 2.6 | 4 | 2.0 | 1.18 |
| Keep Constant | 181 | 92.3 | 186 | 94.9 | |

Experimental firms ("Experimentals") belong to the two percentiles of sample firms with the most extreme negative and the most extreme positive returns in $t-1$. Control firms ("Controls") belong to the two percentiles with the least extreme negative and the least extreme positive returns in $t-1$. Control firms are matched to experimental firms based on the market value in $t-2$ and the 2-digit SIC code in $t-2$. The $\chi^2$-test compares the number of control firms that increase, decrease and keep constant the number of subjective or objective non-financial performance measures to the number of experimental firms that increase, decrease and keep constant the number of subjective or objective non-financial performance measures *** (**) [*] denotes significance at the 1% (5%) [10%] level.

Table G.13: The number of firms using subjective and objective non-financial performance measures

Number (#) and percentage (%) of firms that report using and that do not report using subjective and objective non-financial performance measures in the year of the economic shock, $t-1$, and the year after, $t$

| | | Experimentals | | Controls | | $\chi^2$ |
|---|---|---|---|---|---|---|
| | | # | % | # | % | |
| | | (1) | (2) | (3) | (4) | (5) |
| **A. All subjective performance measures** | | | | | | |
| $t-1$ | report | 139 | 70.9 | 140 | 71.4 | 0.01 |
| | do not report | 57 | 29.1 | 56 | 28.6 | |
| $t$ | report | 149 | 76.0 | 125 | 63.8 | 6.98*** |
| | do not report | 47 | 24.0 | 71 | 36.2 | |
| **A.1. Subjective financial and individual performance measures** | | | | | | |
| $t-1$ | report | 102 | 52.0 | 90 | 45.9 | 1.47 |
| | do not report | 94 | 48.0 | 106 | 54.1 | |
| $t$ | report | 117 | 59.7 | 84 | 42.9 | 11.12*** |
| | do not report | 79 | 40.3 | 112 | 57.1 | |
| **A.2. Subjective non-financial performance measures** | | | | | | |
| $t-1$ | report | 70 | 35.7 | 64 | 32.7 | 0.41 |
| | do not report | 126 | 64.3 | 132 | 67.3 | |
| $t$ | report | 80 | 40.3 | 53 | 27.0 | 8.30*** |
| | do not report | 116 | 59.2 | 143 | 73.0 | |
| **B. Objective non-financial performance measures** | | | | | | |
| $t-1$ | report | 28 | 14.3 | 16 | 8.2 | 3.69* |
| | do not report | 168 | 85.7 | 180 | 91.8 | |
| $t$ | report | 29 | 14.8 | 17 | 8.7 | 3.55* |
| | do not report | 167 | 85.2 | 179 | 91.3 | |

Experimental firms ("Experimentals") belong to the two percentiles of sample firms with the most extreme negative and the most extreme positive returns in $t-1$. Control firms ("Controls") belong to the two percentiles with the least extreme negative and the least extreme positive returns in $t-1$. Control firms are matched to experimental firms based on the market value in $t-2$ and the 2-digit SIC code in $t-2$. The $\chi^2$-test compares the frequencies of control firms that report using the various performance measures and those that do not report using them to the frequencies of experimental firms that report using the different performance measures and those that do not report using them, in $t-1$ and in $t$. *** (**) [*] denotes significance at the 1% (5%) [10%] level.

Table G.14: The change in the use of subjective and objective non-financial performance measures

Number (#) and percentage (%) of firms that report changing the use of subjective and objective non-financial performance measures between the year of the economic shock, $t-1$, and the year after, $t$

| | Experimentals | | Controls | | $\chi^2$ |
|---|---|---|---|---|---|
| | # | % | # | % | |
| | (1) | (2) | (3) | (4) | (5) |
| **A. All subjective performance measures** | | | | | |
| Increase | 12 | 6.1 | 2 | 1.0 | |
| Decrease | 2 | 1.0 | 17 | 8.7 | 19.05*** |
| Keep Constant | 182 | 92.9 | 177 | 90.3 | |
| **A.1. Subjective financial and individual performance measures** | | | | | |
| Increase | 17 | 8.7 | 3 | 1.0 | |
| Decrease | 2 | 1.0 | 9 | 4.6 | 14.39*** |
| Keep Constant | 177 | 90.3 | 184 | 93.9 | |
| **A.2. Subjective non-financial performance measures** | | | | | |
| Increase | 15 | 7.7 | 4 | 2.0 | |
| Decrease | 5 | 2.6 | 15 | 9.7 | 11.37*** |
| Keep Constant | 176 | 89.8 | 177 | 90.3 | |
| **B. Objective non-financial performance measures** | | | | | |
| Increase | 4 | 2.0 | 4 | 2.0 | |
| Decrease | 3 | 1.5 | 3 | 1.5 | 0.20 |
| Keep Constant | 189 | 96.4 | 189 | 96.4 | |

A firm increases [decreases] the use of subjective or objective non-financial performance measures if it does not [does] mention them in their proxy statement in $t-1$, but does [does not] mention them in their proxy statement in $t$. Experimental firms ("Experimentals") belong to the two percentiles of sample firms with the most extreme negative and the most extreme positive returns in $t-1$. Control firms ("Controls") belong to the two percentiles with the least extreme negative and the least extreme positive returns in $t-1$. Control firms are matched to experimental firms based on the market value in $t-2$ and the 2-digit SIC code in $t-2$. The $\chi^2$-test compares the frequencies of control firms that increase, decrease and keep constant the reported use of subjective or non-financial performance measures to the frequencies of experimental firms that increase, decrease and keep constant the reported use of subjective or objective non-financial performance measures. *** (**) [*] denotes significance at the 1% (5%) [10%] level.

Table G.15: The effect of estimation risk on the relation between CEO cash pay and earnings: various risk proxies

$$
\begin{aligned}
C_{i,t} &= a_0 + b_0 A_{i,t} + \mathbf{b_1 A_{i,t} EstimationRisk} + c_1 EstimationRisk \\
&+ g_1 A_{i,t} B/M_{i,t} + g_2 A_{i,t} Risk_{i,t} + g_3 A_{i,t} \psi_i + g_4 A_{i,t} Own_{i,t} + g_5 A_{i,t} Tenure_{i,t} \\
&+ h_0 r_{i,t} + h_\tau r_{i,t-\tau} + \Gamma K + \varepsilon_{i,t}
\end{aligned}
$$

| Coefficient | Independent Variable | Predicted Sign | $Risk_{i,t}$ defined following | Lambert and Larcker (1987) | Sloan (1993) | St. Dev. of $A_{i,t}$ |
|---|---|---|---|---|---|---|
| | | | (1) | (2) | (3) | (4) |
| | | | **A. EstimationRisk = $Disp_{i,t-1}$** | | | |
| $b_0$ | $A_{i,t}$ | + | 0.146 | 0.948*** | 0.083 | 0.014 |
| | | | (0.80) | (3.07) | (0.31) | (0.05) |
| $b_1$ | $A_{i,t}Disp_{i,t-1}$ | - | -0.486*** | -0.460*** | -0.559*** | -0.567*** |
| | | | (-3.78) | (-3.19) | (-3.72) | (-3.99) |
| $c_1$ | $Disp_{i,t-1}$ | ? | 0.033* | 0.033* | 0.037** | 0.040** |
| | | | (1.76) | (1.74) | (1.96) | (2.17) |
| $g_2$ | $A_{i,t}Risk_{i,t}$ | - | | -1.040*** | -0.232** | -0.002*** |
| | | | | (-6.04) | (-2.01) | (-4.35) |
| Adjusted $R^2$ | | | 22.2% | 23.1% | 22.5% | 22.8% |
| # of observations | | | 11,078 | 10,873 | 10,653 | 10,873 |
| | | | **B. EstimationRisk = $\|\|r_{i,t-\tau}\|\|$** | | | |
| $b_0$ | $A_{i,t}$ | + | 0.289 | 1.265*** | 0.312 | 0.367* |
| | | | (1.37) | (4.81) | (1.32) | (1.65) |
| $b_1$ | $A_{i,t}\|\|r_{i,t-1}\|\|$ | - | -0.596*** | -0.593*** | -0.629*** | -0.644*** |
| | | | (-5.89) | (-6.00) | (-6.11) | (-6.46) |
| $b_2$ | $A_{i,t}\|\|r_{i,t-2}\|\|$ | - | -0.339*** | -0.413*** | -0.397*** | -0.404** |
| | | | (-3.42) | (-4.03) | (-3.62) | (-3.78) |
| $b_3$ | $A_{i,t}\|\|r_{i,t-3}\|\|$ | - | -0.037 | -0.051 | 0.022 | 0.001 |
| | | | (-0.43) | (-0.60) | (0.24) | (0.99) |
| $c_1$ | $\|\|r_{i,t-1}\|\|$ | ? | 0.08** | 0.030** | 0.030** | 0.032*** |
| | | | (2.28) | (2.45) | (2.45) | (2.60) |
| $c_2$ | $\|\|r_{i,t-2}\|\|$ | ? | 0.037*** | 0.049*** | 0.048*** | 0.048*** |
| | | | (2.95) | (3.84) | (3.68) | (3.68) |
| $c_3$ | $\|\|r_{i,t-3}\|\|$ | ? | 0.030** | 0.036*** | 0.029** | 0.032** |
| | | | (2.34) | (2.85) | (2.24) | (2.50) |
| $g_2$ | $A_{i,t}Risk_{i,t}$ | - | | -1.030*** | -0.026 | -0.003*** |
| | | | | (-6.45) | (-0.27) | (-3.87) |
| Adjusted $R^2$ | | | 21.8% | 22.3% | 21.7% | 21.9% |
| # of observations | | | 12,848 | 12,523 | 12,273 | 12,523 |

$C_{i,t}$ is the natural logarithm of CEO cash pay (the sum of salary and bonus pay) for firm $i$ in year $t$. $A_{i,t}$ is earnings, defined as income before extraordinary items and discontinued operations (COMPUSTAT #18) divided by prior-year total assets (COMPUSTAT #6). $Disp_{i,t-1}$ is the ranked standard deviation of analysts forecasts made during $t-1$ for earnings in $t$. $||r_{i,t-\tau}||$ is the ranked absolute value of market-adjusted returns in $t-\tau$ (with $\tau$ equal to 1, 2, or 3). $Risk_{i,t}$ according to Lambert and Larcker (1987) is the ranked ratio of the risk in earnings to the risk in returns. Risk in earnings is the variance of earnings over the five years preceding $t$, while risk in returns is the variance of monthly market-adjusted returns over the 60 months preceding $t$. $Risk_{i,t}$ according to Sloan (1993) is the ranked ratio of risk in returns to risk in earnings, and calculated as follows. First, the market model is estimated over the 5 years prior to $t$, with annual raw returns (equally-weighted market returns) cumulated over 12 months as a dependent (independent) variable. Risk in returns is the variance of the market model slope times the equally weighted market index, and is calculated over the 5 years prior to $t$. Next, risk in earnings is estimated as follows. First, earnings are regressed on the residuals from the market model over the 5 years prior to $t$. This regression's residuals are scaled by its slope, and the variance of the scaled residuals is calculated over the 5 years prior to $t$. $Risk_{i,t}$ based on the standard deviation of earnings is the ranked standard deviation of earnings $A_{i,t}$ over the five years prior to $t$. *All variables are further described in Appendix D.* The regressions are estimated from 1992 to 2004 in the pooled cross-section using fixed effects estimation, with effects for CEOs and fiscal years. To keep the size of the table manageable, only the relevant variables are displayed. $t$-statistics (in parentheses) are computed with standard errors adjusted for heteroscedasticity using the White correction.

Table G.16: The impact of the performance standard $A_{i,t-1}$ on how estimation risk affects the relation between CEO cash pay and earnings

$$C_{i,t} = a_0 + \mathbf{b_1 A_{i,t} EstimationRisk} + b_0' A_{i,t-1} + \mathbf{b_1' A_{i,t-1} EstimationRisk} + c_1 EstimationRisk + \Omega A_{i,t} CV + \Omega' A_{i,t-1} * CV + h_0 r_{i,t} + h_\tau r_{i,t-\tau} + \Gamma K + \varepsilon_{i,t}$$

| Coefficient | Independent Variable | Predicted Sign | (1) | Coefficient | Independent Variable | Predicted Sign | (2) |
|---|---|---|---|---|---|---|---|
| | | | **A. EstimationRisk = $Disp_{i,t-1}$** | | | | |
| $b_0$ | $A_{i,t}$ | + | 1.104*** | $b_0'$ | $A_{i,t-1}$ | - | -19.10* |
| | | | (3.44) | | | | (-1.70) |
| $b_1$ | $A_{i,t}Disp_{i,t-1}$ | - | -0.527*** | $b_1'$ | $A_{i,t-1}Disp_{i,t-1}$ | + | 12.53*** |
| | | | (-3.58) | | | | (3.36) |
| $c_1$ | $Disp_{i,t-1}$ | ? | 0.010 | | | | |
| | | | (0.62) | | | | |
| Adjusted $R^2$ | | | | | | | 23.9% |
| # of observations | | | | | | | 10,873 |
| | | | **B. EstimationRisk = $\|\|r_{i,t-\tau}\|\|$** | | | | |
| $b_0$ | $A_{i,t}$ | + | 1.499*** | $b_0'$ | $A_{i,t-1}$ | - | -1.12*** |
| | | | (5.63) | | | | (-4.89) |
| $b_1$ | $A_{i,t}\|\|r_{i,t-1}\|\|$ | - | -0.700*** | $b_1'$ | $A_{i,t-1}\|\|r_{i,t-1}\|\|$ | + | 0.307*** |
| | | | (-6.17) | | | | (2.99) |
| $b_2$ | $A_{i,t}\|\|r_{i,t-2}\|\|$ | - | -0.227** | $b_2'$ | $A_{i,t-1}\|\|r_{i,t-2}\|\|$ | + | -0.131 |
| | | | (-2.17) | | | | (-1.29) |
| $b_3$ | $A_{i,t}\|\|r_{i,t-3}\|\|$ | - | -0.192** | $b_3'$ | $A_{i,t-1}\|\|r_{i,t-3}\|\|$ | + | 0.199** |
| | | | (-2.05) | | | | (2.28) |
| $c_1$ | $\|\|r_{i,t-1}\|\|$ | ? | 0.015 | | | | |
| | | | (1.17) | | | | |
| $c_2$ | $\|\|r_{i,t-2}\|\|$ | ? | 0.045*** | | | | |
| | | | (3.43) | | | | |
| $c_3$ | $\|\|r_{i,t-3}\|\|$ | ? | 0.030** | | | | |
| | | | (2.46) | | | | |
| $p$-value for $b_1 = b_2$ | | | < 0.01 | $p$-value for $b_1' = b_2'$ | | | < 0.01 |
| $p$-value for $b_2 = b_3$ | | | 0.818 | $p$-value for $b_2' = b_3'$ | | | 0.534 |
| $p$-value for $b_1 = b_3$ | | | < 0.01 | $p$-value for $b_1' = b_3'$ | | | 0.407 |
| Adjusted $R^2$ | | | | | | | 22.7% |
| # of observations | | | | | | | 12,522 |

$C_{i,t}$ is the natural logarithm of CEO cash pay (the sum of salary and bonus pay) for firm $i$ in year $t$. $A_{i,t}$ is earnings for firm $i$ in $t$, defined as income before extraordinary items and discontinued operations (COMPUSTAT #18) divided by prior-year total assets (COMPUSTAT #6). $A_{i,t-1}$ is earnings for firm $i$ in $t-1$. $Disp_{i,t-1}$ is the ranked standard deviation of analysts forecasts made during $t-1$ for earnings in $t$. $||r_{i,t-\tau}||$ is the ranked absolute value of market-adjusted returns in $t-\tau$ (with $\tau$ equal to 1, 2, or 3). All variables are defined as in Appendix D. The regressions are estimated from 1992 to 2004 in the pooled cross-section using fixed effects estimation, with effects for CEOs and fiscal years. To keep the size of the table manageable, only the relevant variables are displayed. $t$-statistics (in parentheses) and $p$-values [in brackets] are computed with standard errors adjusted for heteroscedasticity using the White correction.

Table G.17: Probit regression for predicting CEO bonus awards

$$\begin{aligned} Bonus_{i,t} = {} & \delta_0 + \delta_1 A_{i,t} + \delta_2 Threshold_{A_{i,t}} + \delta_3 DA_{i,t} + \delta_4 r_{i,t} + \delta_5 r_{i,t-1} + \delta_6 r_{i,t-2} + \delta_7 r_{i,t-3} + \delta_8 BonInd_{i,t} + \delta_9 Cash_{i,t} + \delta_{10} Debt_{i,t} \\ & + \delta_{11} B/M_{i,t} + \delta_{12} Vol_{i,t} + \delta_{13} Size_{i,t} + \delta_{14} Own_{i,t} + \delta_{15} Chair_{i,t} + \delta_{16} Tenure_{i,t} + \delta_{17} Meet_{i,t} + \delta_{18} Interlock_{i,t} + \varepsilon_{i,t} \end{aligned}$$

| Coefficient | Independent Variable | Predicted Sign | Estimated value ($\chi^2$-statistic) (1) | Marginal effect (2) | Coefficient | Independent Variable | Predicted Sign | Estimated value ($t$-statistic) (3) | Marginal effect (4) |
|---|---|---|---|---|---|---|---|---|---|
| $\delta_0$ | Intercept | | -1.94*** | -0.425 | $\delta_{10}$ | $Debt_{i,t}$ | - | -0.300*** | -0.066 |
| | | | (35.97) | | | | | (10.17) | |
| $\delta_1$ | $A_{i,t}$ | + | -0.080 | -0.018 | $\delta_{11}$ | $B/M_{i,t}$ | ? | -0.115* | -0.025 |
| | | | (0.69) | | | | | (2.77) | |
| $\delta_2$ | $Threshold_{A_{i,t}}$ | + | 0.474*** | 0.119 | $\delta_{12}$ | $Vol_{i,t}$ | + | -1.277*** | -0.280 |
| | | | (190.05) | | | | | (15.90) | |
| $\delta_3$ | $DA_{i,t}$ | - | -0.569*** | -0.159 | $\delta_{13}$ | $Size_{i,t}$ | + | 0.050*** | 0.011 |
| | | | (137.43) | | | | | (14.51) | |
| $\delta_4$ | $r_{i,t}$ | + | 0.451*** | 0.099 | $\delta_{14}$ | $Own_{i,t}$ | ? | -0.082*** | -0.018 |
| | | | (167.45) | | | | | (86.68) | |
| $\delta_5$ | $r_{i,t-1}$ | + | 0.260*** | 0.057 | $\delta_{15}$ | $Chair_{i,t}$ | + | 0.084** | 0.020 |
| | | | (46.42) | | | | | (5.90) | |
| $\delta_6$ | $r_{i,t-2}$ | + | 0.152*** | 0.033 | $\delta_{16}$ | $Tenure_{i,t}$ | + | -0.056** | -0.012 |
| | | | (19.57) | | | | | (5.61) | |
| $\delta_7$ | $r_{i,t-3}$ | + | 0.140*** | 0.031 | $\delta_{17}$ | $Meet_{i,t}$ | - | -0.008 | -0.002 |
| | | | (16.48) | | | | | (2.15) | |
| $\delta_8$ | $BonInd_{i,t}$ | + | 3.139*** | 0.689 | $\delta_{18}$ | $Interlock_{i,t}$ | + | -0.165*** | -0.041 |
| | | | (332.09) | | | | | (10.69) | |
| $\delta_9$ | $Cash_{i,t}$ | - | 0.049 | 0.011 | | Year Dummies | | | Insignificant |
| | | | (0.41) | | | Industry Dummies | | | Significant |
| Likelihood Ratio $\chi^2$ | | | 9,553.85 | | | | | | |
| # of observations | | | 12,087 | | | | | | |

This regression estimates the probability that the CEO of firm $i$ earns a bonus in fiscal year $t$, using data between 1992 and 2004. $Bonus_{i,t}$ is a dummy that equals 1 if the CEO earns a bonus in year $t$, and 0 otherwise. The regression is estimated using a probit model in the pooled cross-section with year and industry dummies (defined by two-digit SIC code) from 1992 to 2004. $Threshold_{A_{i,t}}$ equals 1 if earnings $A_{i,t}$ are greater than 80% of prior-year earnings $A_{i,t-1}$, and 0 otherwise. $DA_{i,t}$ equals 1 if earnings $A_{i,t}$ are strictly negative, and 0 otherwise. $BonInd_{i,t}$ is the percentage of firms in firm $i$'s industry that allocate a bonus to their CEO in year $t$. $Cash_{i,t}$ captures the firm's cash constraints. $Debt_{i,t}$ is the firm's debt. Appendix D provides more details on these and all other variables. $\chi^2$-statistics are reported in parentheses.

Table G.18: The impact of the lower bonus bound on how estimation risk affects the relation between CEO cash pay and earnings

$$C_{i,t} = a_0 + \mathbf{b_1 A_{i,t} EstimationRisk} + c_1 EstimationRisk + \Omega A_{i,t} CV + h_0 r_{i,t} + h_\tau r_{i,t-\tau} + \Gamma K + \lambda MillsRatio + \varepsilon_{i,t}$$

| Coefficient | Independent Variable | Predicted Sign | (1) | Adjusted $R^2$ | # of observations |
|---|---|---|---|---|---|
| | **A. EstimationRisk = $\mathbf{Disp_{i,t-1}}$** | | | | |
| $b_0$ | $A_{i,t}$ | + | 0.438* | 31.0% | 8,267 |
| | | | (1.86) | | |
| $b_1$ | $A_{i,t}Disp_{i,t-1}$ | - | -0.398*** | | |
| | | | (-3.51) | | |
| $c_1$ | $Disp_{i,t-1}$ | ? | 0.017 | | |
| | | | (0.29) | | |
| $\lambda$ | Mills Ratio | | -0.181*** | | |
| | | | (-9.98) | | |
| | **B. EstimationRisk = $\mathbf{\|\|r_{i,t-\tau}\|\|}$** | | | | |
| $b_0$ | $A_{i,t}$ | + | 0.648*** | 29.6% | 9,453 |
| | | | (3.16) | | |
| $b_1$ | $A_{i,t}\|\|r_{i,t-1}\|\|$ | - | -0.389*** | | |
| | | | (-5.21) | | |
| $b_2$ | $A_{i,t}\|\|r_{i,t-2}\|\|$ | - | -0.319*** | | |
| | | | (-4.36) | | |
| $b_3$ | $A_{i,t}\|\|r_{i,t-3}\|\|$ | - | -0.077 | | |
| | | | (-1.02) | | |
| $c_1$ | $\|\|r_{i,t-1}\|\|$ | ? | 0.055*** | | |
| | | | (4.95) | | |
| $c_2$ | $\|\|r_{i,t-2}\|\|$ | ? | 0.058*** | | |
| | | | (5.08) | | |
| $c_3$ | $\|\|r_{i,t-3}\|\|$ | ? | 0.038*** | | |
| | | | (3.35) | | |
| $\lambda$ | Mills Ratio | | -0.164*** | | |
| | | | (-9.89) | | |
| $p$-value for $b_1 = b_2$ | | | 0.504 | | |
| $p$-value for $b_2 = b_3$ | | | 0.018 | | |
| $p$-value for $b_1 = b_3$ | | | $< 0.01$ | | |

$C_{i,t}$ is the natural logarithm of CEO cash pay (the sum of salary and bonus pay) for firm $i$ in year $t$. $A_{i,t}$ is earnings, defined as income before extraordinary items and discontinued operations (COMPUSTAT #18) divided by prior-year total assets (COMPUSTAT #6). $Disp_{i,t-1}$ is the ranked standard deviation of analysts forecasts made during $t-1$ for earnings in $t$. $||r_{i,t-\tau}||$ is the ranked absolute value of market-adjusted returns in $t-\tau$ (with $\tau$ equal to 1, 2, or 3). All variables are defined as in Appendix D. This table includes only firm-years where CEOs earn a positive bonus. The above regression is the second stage of a Heckman two-stage model, which controls for sample selection. $MillsRatio_{i,t}$ is the inverse Mills ratio, defined as $\phi(\widehat{\delta_x} x_{i,t})$ divided by $\Phi(\widehat{\delta_x} x_{i,t})$, where $x_{i,t}$ are the independent variables from the probit model, $\phi(\cdot)$ $[\Phi(\cdot)]$ is the standard normal probability density [cumulative distribution] function, and $\widehat{\delta_x}$ are the estimated coefficients from the Probit regression that estimates the probability of a CEO being awarded a bonus as a function of the variables $x_{i,t}$, shown in Table G.17. The regressions in the current table are estimated from 1992 to 2004 in the pooled cross-section using fixed effects estimation, with effects for CEOs and fiscal years. To keep the size of the table manageable, only the relevant variables are displayed. $t$-statistics (in parentheses) are computed with standard errors adjusted for heteroscedasticity using the White correction, and for the fact that the regression includes an estimated variable (the inverse Mills ratio $MillsRatio_{i,t}$), following Greene (1997).

Table G.19: The impact of the lower and the upper bonus bounds on how estimation risk affects the relation between CEO cash pay and earnings

$$C_{i,t} = a_0 + \mathbf{b_1 A_{i,t} EstimationRisk} + c_1 EstimationRisk + d_1 A_{i,t} Up + d_2 Up + \Omega A_{i,t} CV + h_0 r_{i,t} + h_\tau r_{i,t-\tau} + \Gamma K + \lambda MillsRatio + \varepsilon_{i,t}$$

| Coefficient | Independent Variable | Predicted Sign | Upper bound based on Industry earnings $Up = D^I_{i,t}$ (1) | Past earnings $Up = D^A_{i,t}$ (2) |
|---|---|---|---|---|
| | | **A. EstimationRisk = $\mathbf{Disp_{i,t-1}}$** | | |
| $b_0$ | $A_{i,t}$ | + | 0.252 | 0.129 |
| | | | (1.04) | (0.55) |
| $b_1$ | $A_{i,t}Disp_{i,t-1}$ | - | -0.367*** | -0.377*** |
| | | | (-3.23) | (-3.33) |
| $c_1$ | $Disp_{i,t-1}$ | ? | -0.003 | 0.014 |
| | | | (-0.20) | (0.88) |
| $d_1$ | $A_{i,t}Up$ | - | 0.056 | 0.151*** |
| | | | (0.68) | (2.81) |
| $d_2$ | $Up$ | + | 0.044*** | 0.048*** |
| | | | (2.92) | (6.49) |
| $\lambda$ | Mills Ratio | | -0.181*** | -0.153*** |
| | | | (-10.01) | (-8.24) |
| Adjusted $R^2$ | | | 31.3% | 31.9% |
| # of observations | | | 8,267 | 8,267 |
| | | **B. EstimationRisk = $\mathbf{\|\|r_{i,t-\tau}\|\|}$** | | |
| $b_0$ | $A_{i,t}$ | + | 0.456*** | 0.361* |
| | | | (2.10) | (1.73) |
| $b_1$ | $A_{i,t}\|\|r_{i,t-1}\|\|$ | - | -0.348*** | -0.348*** |
| | | | (-4.59) | (-4.63) |
| $b_2$ | $A_{i,t}\|\|r_{i,t-2}\|\|$ | - | -0.302*** | -0.272*** |
| | | | (-3.92) | (-3.56) |
| $b_3$ | $A_{i,t}\|\|r_{i,t-3}\|\|$ | - | -0.071 | -0.055 |
| | | | (-0.90) | (-0.70) |
| $c_1$ | $\|\|r_{i,t-1}\|\|$ | ? | 0.051*** | 0.049*** |
| | | | (4.50) | (4.38) |
| $c_2$ | $\|\|r_{i,t-2}\|\|$ | ? | 0.056*** | 0.058*** |
| | | | (4.78) | (4.95) |
| $c_3$ | $\|\|r_{i,t-3}\|\|$ | ? | 0.039*** | 0.036*** |
| | | | (3.25) | (3.07) |
| $d_1$ | $A_{i,t}Up$ | - | 0.062 | 0.118*** |
| | | | (0.81) | (2.61) |
| $d_2$ | $Up$ | + | 0.040*** | 0.045*** |
| | | | (3.23) | (6.79) |
| $\lambda$ | Mills Ratio | | -0.168 | -0.136 |
| | | | (-10.08) | (-7.94) |
| $p$-value for $b_1 = b_2$ | | | 0.670 | 0.480 |
| $p$-value for $b_2 = b_3$ | | | 0.040 | 0.052 |
| $p$-value for $b_1 = b_3$ | | | < 0.01 | < 0.01 |
| Adjusted $R^2$ | | | 29.9% | 30.3% |
| # of observations | | | 9,453 | 9,453 |

$C_{i,t}$ is the natural logarithm of CEO cash pay (the sum of salary and bonus pay) for firm $i$ in year $t$. $A_{i,t}$ is earnings, defined as income before extraordinary items and discontinued operations (COMPUSTAT #18) divided by prior-year total assets (COMPUSTAT #6). $Disp_{i,t-1}$ is the ranked standard deviation of analysts forecasts made during $t-1$ for earnings in $t$. $||r_{i,t-\tau}||$ is the ranked absolute value of market-adjusted returns in $t-\tau$ (with $\tau$ equal to 1, 2, or 3). $Up$ controls for the presence of an upper bonus bound, and is either $D^I_{i,t}$ or $D^A_{i,t}$. $D^I_{i,t}$ is 1 if $A_{i,t}$ belongs to the highest earnings quintile, by fiscal year and 2-digit SIC industry, and 0 otherwise. $D^A_{i,t}$ is 1 if $A_{i,t}$ is higher than 120% of $t-1$ earnings, and 0 otherwise. All variables are defined as in Appendix D. This table includes only firm-years where CEOs earn a bonus. The above regression is the second stage of a Heckman two-stage model, which controls for sample selection. $MillsRatio_{i,t}$ is the inverse Mills ratio, defined as $\phi(\widehat{\delta_x} x_{i,t})$ divided by $\Phi(\widehat{\delta_x} x_{i,t})$, where $x_{i,t}$ are the independent variables from the probit model, $\phi(\cdot)$ [$\Phi(\cdot)$] is the standard normal probability density [cumulative distribution] function, and $\widehat{\delta_x}$ are the estimated coefficients from the Probit regression that estimates the probability of a CEO being awarded a bonus as a function of the variables $x_{i,t}$, shown in Table G.17. The regressions in the current table are estimated from 1992 to 2004 in the pooled cross-section using fixed effects estimation, with effects for CEOs and fiscal years. To keep the size of the table manageable, only the relevant variables are displayed. $t$-statistics (in parentheses) are computed with standard errors adjusted for heteroscedasticity using the White correction, and for the fact that the regressions include an estimated variable (the inverse Mills ratio $MillsRatio_{i,t}$), following Greene (1997).

Table G.20: The first difference specification

$$\Delta C_{i,t} = a_0 + b_0 \Delta A_{i,t} + \mathbf{b}_\tau \mathbf{\Delta A_{i,t} EstimationRisk} + c_\tau \Delta EstimationRisk$$
$$+ g_1 \Delta A_{i,t} B/M_{i,t} + g_2 \Delta A_{i,t} Noise_{i,t} + g_3 \Delta A_{i,t} \psi_i + g_4 \Delta A_{i,t} Own_{i,t} + g_5 \Delta A_{i,t} Tenure_{i,t}$$
$$+ h_0 \Delta r_{i,t} + h_\tau \Delta r_{i,t-\tau} + \Gamma \Delta K + \varepsilon_{i,t}$$

| Coefficient | Independent Variable | Predicted Sign | (1) |
|---|---|---|---|
| **A. EstimationRisk = $\mathbf{Disp_{i,t-1}}$** | | | |
| $b_0$ | $\Delta A_{i,t}$ | + | 1.475*** |
| | | | (4.30) |
| $b_1$ | $\Delta A_{i,t} Disp_{i,t-1}$ | - | -0.345*** |
| | | | (-2.37) |
| $c_1$ | $Disp_{i,t-1}$ | ? | 0.122*** |
| | | | (6.27) |
| Adjusted $R^2$ | | | 13.7% |
| # of observations | | | 7,877 |
| **B. EstimationRisk = $\mathbf{\|\|r_{i,t-\tau}\|\|}$** | | | |
| $b_0$ | $\Delta A_{i,t}$ | + | 1.987*** |
| | | | (3.03) |
| $b_1$ | $\Delta A_{i,t} \|\|r_{i,t-1}\|\|$ | - | -0.452*** |
| | | | (-4.03) |
| $b_2$ | $\Delta A_{i,t} \|\|r_{i,t-2}\|\|$ | - | -0.422*** |
| | | | (-3.33) |
| $b_3$ | $\Delta A_{i,t} \|\|r_{i,t-3}\|\|$ | - | 0.022 |
| | | | (0.19) |
| $c_1$ | $\Delta \|\|r_{i,t-1}\|\|$ | ? | 0.011 |
| | | | (0.43) |
| $c_2$ | $\Delta \|\|r_{i,t-2}\|\|$ | ? | 0.018 |
| | | | (0.26) |
| $c_3$ | $\Delta \|\|r_{i,t-3}\|\|$ | ? | 0.02 |
| | | | (0.88) |
| $p$-value for $b_1 < b_2$ | | | 0.819 |
| $p$-value for $b_2 < b_3$ | | | 0.008 |
| $p$-value for $b_1 < b_3$ | | | 0.004 |
| Adjusted $R^2$ | | | 3.91% |
| # of observations | | | 9,342 |

The variable $\Delta$ in front of a variable indicates that this variable is considered in its first difference (the level of the variable in year $t$ minus the level of the variable in year $t-1$). $C_{i,t}$ is the natural logarithm of CEO cash pay (the sum of salary and bonus pay) for firm $i$ in year $t$. $A_{i,t}$ is earnings, defined as income before extraordinary items and discontinued operations (COMPUSTAT #18) divided by prior-year total assets (COMPUSTAT #6). $Disp_{i,t-1}$ is the ranked standard deviation of analysts forecasts made during $t-1$ for earnings in $t$. $||r_{i,t-\tau}||$ is the ranked absolute value of market-adjusted returns in $t-\tau$ (with $\tau$ equal to 1, 2, or 3). All variables are defined as in Appendix D. The regressions are estimated from 1993 to 2004 in the pooled cross-section, using the first difference specification. To keep the size of the table manageable, only the relevant variables are displayed. $t$-statistics (in parentheses) and $p$-values are computed with standard errors adjusted for heteroscedasticity using the White correction.