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CEO compensation: Too Much is Not Enough !

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Abstract

This paper conducts an analysis of the relationship between CEO compensation and managerial performance on a large panel of US public firms, by taking into account the different components of CEO compensation. We estimate a stochastic frontier model in which managerial performance is related to compensation components. We find a positive and significant influence of CEO compensation on managerial performance, with a differentiated impact for components of compensation. We show that increases in salary, bonus, and options grants tend to enhance managerial performance. Our findings tend therefore to support the view that compensation contracts can be designed to increase managerial performance.

Keywords: executive compensation, corporate governance, stochastic frontier.

JEL Classification: C30, G30, J33.

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Abstract

This paper conducts an analysis of the relationship between CEO compensation and managerial performance on a large panel of US public firms, by taking into account the different components of CEO compensation. We estimate a stochastic frontier model in which managerial performance is related to compensation components. We find a positive and significant influence of CEO compensation on managerial performance, with a differentiated impact for components of compensation. We show that increases in salary, bonus, and options grants tend to enhance managerial performance. Our findings tend therefore to support the view that compensation contracts can be designed to increase managerial performance.

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1. Introduction

CEO compensation has received a great deal of attention from the public in recent years owing to the strong increase of CEO pay and the widespread use of stock options. Both of these issues are intertwined as the remarkable increase of CEO compensation is due to the emergence of stock options associated with greater other components of compensation. This evolution has contributed to favor a common view according to which CEOs would be overpaid. It might indeed be the case that greater CEO compensation, by increasing inequality, hampers welfare, given that most people are reluctant to accept inequality. However in order to know if CEOs are overpaid, an investigation from the firm perspective is needed to check whether increased CEO compensation is beneficial for companies in the sense that ultimate benefits exceed costs of CEO compensation. It is indeed of utmost interest to check whether there are economic justifications for high levels of CEO compensation. This leads to the issue of the existence of a positive link between CEO compensation and firm performance.

Theoretical arguments in favor of such a link are all based on agency theory, following the separation of ownership and management in publicly traded companies (Berle and Means, 1932). An agency conflict therefore emerges between the manager and the shareholders (Jensen and Meckling, 1976). Managers may use their discretionary power to gain some personal benefits through a variety of means, including empire building, entrenchment strategies, and also reduction of their effort (Shleifer and Vishny, 1997). Consequently, executive compensation plans should be designed to align the interests of executives with those of shareholders.

In other words, such plans should be implemented so that executive compensation is influenced by their efforts and their ability in managerial performance, as summarized by Murphy (1986, p.60): "the level of managerial effort chosen by an executive depends on his incentive contract". This so-called "optimal contracting approach" considers that executive compensation schemes would be designed to favor managerial performance by providing them incentives to provide their optimal effort. Therefore, according to this view and to the assumption of rationality of shareholders leading to optimal compensation arrangements, we should observe a positive impact of CEO compensation on managerial performance.

However Bebchuk and Fried (2003, 2004) contest this view by developing the argument that executive compensation is not an instrument to address the agency problem, but a consequence of this problem. Indeed, they consider that executive compensation reflects in fact the discretionary power of managers. Consequently, greater compensation would not favor better managerial performance, but would be the result of stronger managerial power.

As a result, we should not observe a positive relationship between CEO compensation and managerial performance, as performance would not influence CEO compensation. We could even expect a negative link if we consider that stronger managerial power is linked to both greater CEO compensation and greater relaxing of effort.

There is consequently a strong need for evidence on the impact of CEO compensation on managerial performance in order to assess the relevance of greater CEO compensation and of stock options.

The empirical literature is however not very helpful on this topic. Indeed, most papers focus on the opposite link according to which greater performance should favor greater compensation, as surveyed by Murphy (1999). Hall and Liebman (1998) notably investigate the sensitivity of CEO compensation to variations of the stock price. The underlying motivation of these studies is to check whether managers really benefit from positive changes of the stock price resulting from their decisions. While such relationship is very likely for components of compensation dealing with stock price (CEO holdings of stock and stock options), one could wonder whether other components such as salary and bonus are influenced by stock performance. The conclusion of this literature is that CEO pay is influenced by stock performance almost only through changes in the value of CEO holdings, meaning not through changes in other components.

Such literature reveals interesting evidence on the link between compensation and firm performance, by explaining whether firm performance influences compensation and how. But it only provides indirect information on the incentives generated with compensation for performance. Indeed the fact that compensation is influenced by firm performance suggests that CEOs are motivated to perform well. Nevertheless, such view assumes a perfect rationality of CEOs regarding this link, and notably through salary.

Consequently, the investigation of the incentives generated with compensation for firm performance requires a more direct analysis, looking into the magnitude of the influence of CEO compensation on firm performance.

A notable paper on this topic is Habib and Ljungqvist (2005). They adopt the frontier efficiency techniques to estimate the ratio of the optimal Tobin's Q to the current Tobin's Q for a large sample of US companies. They consider that such ratio estimates the magnitude of agency costs between managers and shareholders. They are subsequently able to investigate whether stock components of CEO compensation (stocks and stock options) contribute to exert a positive impact on firm value by reducing agency costs. They support the role of incentives through stockholdings and optionholdings on the ability to reach the optimal Tobin's Q. Therefore, this paper brings evidence on the impact of CEO compensation but it does not directly estimate managerial performance, using a proxy through the ability to reach the optimal Tobin's Q. Furthermore, it does not investigate the possible influence of non-stock components of compensation.

The aim of our paper is to provide new evidence on the impact of CEO compensation on managerial performance. Our contribution is based on two major additions to this literature. The first addition is the use of frontier efficiency techniques to estimate managerial performance. That is to say, a production frontier is estimated which allows the comparison of each firm to the best-practice companies. As a result, the technical efficiency score assesses how close a firm's production is to what a firm's optimal production would be for using the same bundle of inputs. It therefore brings information on the managerial performance of the firm. To this end, we adopt the Battese and Coelli (1995)'s stochastic frontier model allowing to assess the link between CEO compensation and technical efficiency.

The second addition is the use of an extensive dataset, which contains information on all components of executive compensation on a large panel of US public firms. This dataset allows investigating the differentiated impact on managerial performance of each component of compensation, meaning mainly salary, annual bonus, option grants and stocks grants, and changes in the value of stock-options.

As a consequence, our paper answers two fundamental questions for the understanding of the incentives connected with CEO compensation: is greater CEO compensation associated with greater managerial performance? Have all components of compensation the same impact on managerial performance?

Both questions are of utmost interest owing to their normative implications for corporate governance. Thus a positive answer to the first question might provide some support for the absence of a ceiling for CEO compensation. Furthermore, the answer to the second question gives some insights to the economic justification of the expansion of stock-options for the regulator. It will also give information to shareholders on which components of compensation should be enhanced to improve managerial performance. They may consequently be able to implement an optimal executive compensation scheme in terms of compensation costs for the company.

The structure of the paper is as follows. Section 2 presents the methodology used for the efficiency measures. Section 3 describes the data and variables. In section 4, we develop the empirical results. Finally, we provide some concluding remarks in section 5.

2. Methodology

Our paper aims at investigating the relationship between CEO compensation and managerial performance. Therefore we have first to obtain measures of managerial performance. To this end, we use frontier efficiency techniques. Following seminal works by Aigner, Lovell and Schmidt (1977) and Charnes, Cooper and Rhodes (1978), these methods provide sophisticated measures of managerial performance, the efficiency scores.

We adopt the stochastic frontier approach to estimate efficiency scores. Several advantages can be argued in favor of this approach. First, it provides synthetic measures of performance. Indeed, unlike basic productivity measures (e.g. output per employee), the efficiency scores computed with the stochastic frontier approach allow to include several input and output dimensions in the evaluation of performances. Second, it computes relative measures of performance. That is, a production frontier is estimated which allows the comparison of each firm to the best-practice companies. As a result, the technical efficiency score assesses how close a firm's production is to what a firm's optimal production would be for using the same bundle of inputs. It then directly provides a relative measure of performance.

Third, efficiency frontiers take the scale effects into account. Indeed, with standard productivity ratios, the existence of scale economies may benefit large firms in terms of performance. With technical efficiency scores, the scale effects are disentangled from the "pure" performance measures. Fourth, whereas total factor productivity measures assess performance by the whole residual from the production frontier for each country, the stochastic frontier approach allows to disentangle the distance to the production frontier between an inefficiency term and a random error, taking into account exogenous events.

The basic model of the stochastic frontier approach assumes that production deviates from the optimal production by a random disturbance, v, and an inefficiency term, u. Thus the production frontier is $Y = f(X) + \varepsilon$ where Y represents production, X is the vector of inputs, and ε the error term which is the difference between v and of u. u is a one-sided component representing technical inefficiencies, meaning the degree of weakness of managerial performance. v is a two-sided component representing random disturbances, reflecting luck or measurement errors. u and v are independently distributed. v is assumed to have a normal distribution with zero mean and variance σ_v^2. u is assumed to have a truncated normal with m mean and variance σ_u^2. According to Jondrow et al. [1982], firm-specific estimates of inefficiency terms can be calculated by using the distribution of the inefficiency term conditional upon the estimate of the composite error term.

The investigation of the determinants of efficiency can be done following several procedures. The more straightforward procedure is the so-called "two-stage procedure": the stochastic frontier model is estimated in the first stage, while the obtained efficiency scores are regressed on a set of explanatory variables including compensation in the second stage. Although often applied in the literature, there are two important econometric problems with this two-stage procedure, as observed by Kumbhakar and Lovell (2000). First, it assumes that the efficiency terms are identically distributed in the estimation of the stochastic frontier model of the first stage, while in the second stage this assumption is contradicted by the fact that the regression of the efficiency terms on the explanatory variables suggests that the efficiency terms are not identically distributed. Second, the explanatory variables must be assumed as uncorrelated with the variables of the production frontier, or else the maximum likelihood estimates of the parameters of the production frontier would be biased because of the omission of the explanatory variables in the first stage. But then, the estimated efficiency terms that are explained in the second stage are biased estimates, as they are estimated relative to a biased representation of the production frontier.

Therefore, we rather adopt the "one-stage procedure" proposed by Battese and Coelli (1995), which solves these econometric problems. They propose a procedure using panel data, in which the non-negative inefficiency term is assumed to have a truncated distribution with different means for each firm. As a result, the distributions of the inefficiency terms are not the same, but are expressed as functions of explanatory variables. The inefficiency terms are then independently but not identically distributed. They are obtained by truncation at zero of the $N(\mu_{it}, \sigma_u^2)$ distribution: $\mu_{it} = z_{it}\,\delta$, where z_{it} is a vector of explanatory variables, and δ a vector of parameters to be estimated.

The estimated model includes then two equations: a production frontier function specified in equation (1), and an equation to explain the inefficiencies specified in equation (2). We adopt the translog specification for the production frontier. The model is then specified as follows:

$$\ln Y_{it} = \beta_0 + \beta_1 \ln L_{it} + \beta_2 \ln K_{it} + \beta_3 (\ln L_{it})^2 + \beta_4 (\ln K_{it})^2 + \beta_5 (\ln L_{it})(\ln K_{it}) + \varepsilon_{i,t} \quad (1)$$

where *i* company, *t* year, *Y* production, *L* labor, *K* physical capital, ε the composite error term.

$$u_{it} = \delta z_{it} + W_{it} \quad (2)$$

where u_{it} is the inefficiency, z_{it} is a p*1 vector of explanatory variables, δ is a 1*p vector of parameters to be estimated, W_{it} the random variable defined by the truncation of the normal distribution with mean zero and variance σ^2 ($\sigma^2 = \sigma_u^2 + \sigma_v^2$).

3. Data and variables

3.1. Data

Our final sample includes about 1,109 CEO of US non-financial firms. The sample covers 1992-2002. Given the unbalanced structure of our data, our final sample consists of a total of 5,224 CEO-year observations, representing 948 different firms[1].

In order to measure efficiency for each firm, we need to have the balance sheet and income statement of these firms. We thus extract the financial statements for each firm and each year from the Compustat *Industrial USA* database, edited by Standard & Poor's.

Given the goals of our empirical study, we also need to know the compensation as well as the precise composition of the compensation package for each CEO. These CEO compensation data are extracted from the Compustat *ExecuComp* database, also edited by Standard & Poor's.

Both databases are then matched, by year, firm and CEO. We only keep observations on data coming from the two sources. We then limit our analysis to non-financial companies in order to have a homogenous sample of firms in terms of financial structure. To this end, we drop out of our sample banks, insurance companies and other financial companies (sectors 45 to 48 in the Fama and French (1997) classification). Firms with non-reported industry code are also set aside from our sample. We also exclude another set of observations, namely, when there are less than 3 observations available for a given CEO.

[1] The number of firms is smaller than the number of CEOs, since many firms have had more than one CEO during the time period under study.

We adopted the Tukey box-plot, based on the use of interquartile range, in order to clean the sample data from outliers. Observations with values out of the range defined by the first and third quartiles more or less two times the interquartile range were excluded for the four following ratios: fixed annual salary to sales, total cash compensation to net sales, sales to labor, sales to physical capital. Following this procedure, 1,710 observations are drop out of the sample, leaving our final sample with 5,224 observations.

3.2. Variables

In order to estimate the relationship between CEO compensation and firm efficiency, it is necessary to define variables for input and output quantities for the production frontier estimation. We also have to choose CEO compensation-related variables (*i.e.* explanatory variables) and control variables for the equation relating inefficiency scores to explanatory variables. These three sets of variables are presented in this subsection. The subsection will conclude with usual sample and variable descriptive statistics.

We must define input and output quantities for the estimation of the production frontier. We consider one output, production, and two inputs, labor and physical capital. Production is measured by net sales. Labor is measured by the number of employees, while physical capital is defined as the amortization and depreciation expenses.

To take into account the potential effect of time and industry-related specific features, we also add to our explanatory variables time and industry dummies. In order to limit the number of explanatory variables, we only include 9 industry dummies, following the first digit of the main SIC code for each firm.

Next to the production frontier, our model includes an equation relating inefficiencies to CEO compensation elements and some control variables. In consequence, we must have a set of variables related to the CEO compensation package. These variables should be designed to detect 'incentives' provided to the CEO by the shareholders.

The traditional CEO compensation package includes a cash component and a stock component. To understand its composition, one must note that it is the sum of up to six different elements:

-A fixed annual salary, decided by the board of directors or more frequently by an ad-hoc Compensation Committee.

-An annual bonus (paid or accrued), subject to the achievement of one or more specific goals, frequently directly related to the firm performance (measured as of financial and/or industrial performance…).

-One or more grants each year of employee stock-options (ESO) and/or restricted shares; these grants are in general subject to a "vesting period", of 4 years on average for the stock-options. That is: stock-options granted in 1996 for instance can not be exercised before 2000. Following the same logic, restricted shares must be held for a minimum of four years before they can be sold.

-These grants can be, or not, provided in a Long Term Incentive Plan (LTIP) framework: under an LTIP, the CEO is typically provided with free shares, subject to certain conditions such as remaining in employment throughout a given period of time and if the company met certain performance conditions over the same period.

-One or more items among the following: extra cash, stock or retirement benefits, for special instances, such as hiring (golden hello), firing (golden parachute), retirement, and so on.

-The participation in an employee benefit plan and the right to special benefits, including life insurance and supplemental executive retirement plans (the so-called 'SERP's).

We exclude the last two elements from our following comments and analyses, because of absence of any information on these items. Turning to other compensation items, it's straightforward to define variables for base salary (*Salary*) and annual bonus (*Bonus*), since these data are provided directly by *ExecuComp*. These variables are thus simply the annual dollar value of the compensation element. The LTIP-related variable (*LTIP*) is equally easy to define, because even these plans measure company performance over a period of more than one year (generally three years), the amount paid out to the executive under the LTIP is provided by *Execucomp* and not subject to subsequent changes or adjustments[2].

It's more difficult to define the variables related to employee stock options (ESO). The main difficulties arise from (*i*) the potential divergent appreciations of the stock options' value, (*ii*) the difficulties to correctly value the CEO portfolio of stock-

[2] This variable is related only to cash paid out to the CEO under the *LTIP*. Other forms of payments (restricted or free stocks …) are included in the following variables, *Stocks* and *Options*.

options and (*iii*) specific features of stock-options which make hard to define the real 'incentives' given to the CEO by the stock-options.

(i) Several ESO valuation models coexist. The main model of option valuation, the Black-Scholes and Merton model (see Black and Scholes, 1973 and Merton, 1973), relies upon several hypotheses for which ESOs are not complying. Among all specific features of ESOs, ESOs can only be exercised at the completion of a so-called 'vesting' period, ESOs are frequently non-transferable, subject to stated restrictions, etc. In consequence, ESOs contain specific features that make them substantially different from publicly traded stock options. Above all, one can imagine that, contrary to the B&S main assumption, executives are not well diversified, since a high portion of their wealth is invested in stock and ESO of the firm they manage. These ESOs, computed under the risk-free and no-arbitrage hypotheses with the B&S formula, could then be over-priced[3]. Alternative models are available, but they also rely upon data that is not available for us, such as the total wealth of the CEO. We therefore choose to use the Black-Scholes formula to value them, following nearly all previous studies on the subject (see appendix B for details about hypotheses and models used to value the ESOs portfolio and the stock portfolio) and the FASB 123 proposal.

(ii) The second problem is related to the valuation of the option portfolio: for a given year, an executive owns stock-options from previous grants. If the executive was already present in our database the year of the previous grant, it's easy for us to compute the value of his portfolio. The problem arises when the options were granted before the addition of the CEO to the database. In this case, some assumptions upon the CEO behavior have to be made (see appendix B for details), following the Habib and Ljungqvist (2006) method.

(iii) Last, several alternative variables can be defined. The incentives given to a CEO by a stock-option portfolio could be measured by the change in value of this portfolio – the average delta of the stock-options (*Delta*). Delta then measures the partial derivative of the Black-Scholes stock-option value with respect to the value of the underlying stock. Therefore Delta measures the incentives given by stock options to CEOs. They could also be measured by the stock-option's vega (*Vega*), that is the partial derivative of the Black-Scholes stock-option value with respect to the volatility of the underlying stock. Indeed it is well-known that if firm managers are risk-averse or if they have under-diversified portfolios (because of an excessive share of their

wealth invested in the managed firm), CEOs will tend to choose lower risk projects (i.e. with lower expected NPV) rather than optimal projects (i.e. with maximal NPV). Boards may decide to award stock-options to make managers' wealth more sensitive to risk taking. To create such incentives, the awarded options must have a value narrowly linked to firm risk (Guay, 1999). This link could therefore be proxied with *Vega*, which measures the sensitivity of option value to volatility and then assesses whether managers are incited to invest in risky projects. The incentives could also be measured by the dollar value of the total portfolio held of stock options (*TotalOptions*), or the value of the annual option grant (*YearOptions*). As both latter variables are directly related, we will use them alternatively in our empirical study.

The same variables can be computed for the restricted and non-restricted stocks. Here, the computation of the portfolio value and its evolution is straightforward, since all needed information is provided. The variables are *TotalStocks*, the total dollar value of all the (restricted or not) stocks of the CEO portfolio, and *YearStocks*, the total dollar value of stocks grants to the CEO one given year. We again use alternatively these variables as they are correlated.

Finally, we also adopt a measure of total compensation (*TotalCompensation*), which is the sum of all components of compensation received during one year. In other words, total compensation is the sum of salary, bonus, LTIP, the value of the annual option grant, and the value of the annual stocks grant.

The other explanatory variables are control variables that take corporate governance and industry-related factors into account. Corporate governance issues are controlled with three variables. *Shareholders* is the log of the number of registered shareholders in thousands. *BoardMeetings* is the number of Board meetings during the year. The underlying justification for choosing these proxies for corporate governance is that firms with small number of shareholders (Monsen et al., 1968 and Kamerschen, 1968) and/or with frequent board meetings should have less autonomous or entrenched CEOs (see Byrd and Hickman, 1992). The third control variable is related to the CEO himself: *Dismissed* is equal to 1 if the CEO has been dismissed (not necessarily the year considered) from the firm and 0 otherwise. CEO that are or will be dismissed can be expected to under-perform, all else being equal, compared to other CEOs (see Coughlan and Schmidt, 1985 and Warner et al., 1988).

[3] See Hall and Murphy (2002) or Finnerty (2003).

Industry-related factors are controlled through three variables. *Leverage* indicates the leverage ratio of the firm and is measured by the ratio of total debt to total assets. *Rating* is related to the quality of the borrower. A higher value of the variable means a lower credit quality[4]. Additionally, we include a variable to take the term structure of liabilities: *CurrentLiabilities*, defined as the ratio of short-term liabilities to total liabilities.

3.3. Descriptive statistics

Table 1 displays descriptive statistics. The main variables of interest are related to CEO compensation. Our study relies upon 1,109 CEOs of 948 large American firms, which pay their CEOs a salary and a bonus that respectively average approximately 625,000 and 574,000 dollars per year (see table 1 for descriptive statistics about CEO compensations). As it is well-known, stock option grants are the largest component of compensation, at least if they are valued according to the Merton corrected Black and Scholes formula. The firms included in our sample granted options with an average Black-Scholes value of nearly USD 2.79m each year, but the median is far more modest at only USD 937,000. This divergence can be explained by the presence of some extremely large maximum grant values. The largest grant in our database was provided to Thomas Siebel (USD 294m in 2000), the CEO of Siebel Systems, Inc.

Turning to total compensation, the average value is USD 4.59 m (median: 2.38 m), of which base salary accounts for approximately 25%, annual bonus 15% and stock-options about 40%. Over the time period 1992-2003, the average annual growth rate of CEO total compensation is clearly higher than the average growth rate of wages in the economy: about 9.5% in our sample. Over the same period, the variable (incentive) part of the compensation has more than doubled. One can in fact distinguish two sub-periods. The first one lasts from 1992 to 2000, with a strong and continuous increase in total average compensation. Over that period, the average annual growth rate is higher than 12%. In the period 2001-2003, the annual growth rate fall, with the stock market collapse, the introduction of new accountancy standards in the US (making stock-options more expensive for firms) and an increased vigilance of the shareholders and the public opinion following excesses of the previous period.

[4] This variable takes values from 1 to 6, according to the firm's long term rating, from AAA (coded 1) to D (coded 6). Original credit scores come from Standard and Poor's.

Turning to the descriptive statistics of firms, usual descriptive statistics of the population of firms are provided in table 1. The largest firm in our sample is General Electric Co. (net sales around USD 100b) and the smallest is Verity Inc. (net sales of USD 64m). Table 1 gives additional details about firms included in our sample. Our sample shows a bias towards large firms, which results from the fact it only contains listed firms. It does not represent a severe problem for our investigation as our focus deals with the cost in efficiency of the separation between control and property, which is a feature more frequent in large firms.

4. Results

The discussion of our results is structured as follows. In the first subsection, we estimate the stochastic frontier model including CEO compensation as a possible explanatory variable for inefficiency. The second subsection then displays robustness tests.

4.1 Findings

We estimate the stochastic frontier model in which compensation components are included as explanatory variables of inefficiency. Table 2 displays our results. The first lines exhibit the coefficients of the estimated production frontier, whereas the lower part of the table is devoted to the coefficients of the equation in which inefficiency is explained. One has to keep in mind that a minus sign indicates that an increase in the explanatory variable leads to less inefficiency, that is a rise in efficiency. Several specifications have been tested, which differ on the tested compensation variables.

Our first specification includes *TotalCompensation* as the only tested compensation variable in order to investigate the full impact of CEO compensation on managerial performance (column 1). This estimation shows a negative and significant influence of compensation on inefficiency, suggesting that greater compensation enhances managerial performance. This finding is in accordance with the view of Murphy (1986) according to which compensation contracts can be designed to enhance managerial performance.

We can however wonder whether cash components or stock components of CEO compensation all exert a positive influence on managerial performance. We then adopt a breakdown of CEO compensation to investigate the differentiated impact of components of executive compensation on performance. We include both cash components and stock components. Cash components are *Salary*, *Bonus* and *LTIP*. Regarding stock components, we include *Delta*, *Vega*, and alternatively *TotalStocks* and *TotalOptions* (column 2), or *YearStocks* and *YearOptions* (column 3).

The main conclusion of these estimations is the differentiated impact of components of compensation on managerial performance. Among the cash components, *Salary* and *Bonus* have significantly negative coefficients, whereas *LTIP* is not significant. We therefore tend to support the view that greater salary and bonus enhance managerial performance. Furthermore, greater compensation through grants in the Long Term Incentive Plan is useless in terms of incentives for performance, and should rather be replaced by greater salary or bonus.

Among the stock components, a clear distinction emerges between stocks and stock options. Indeed, the variables *TotalOptions* and *YearOptions* are respectively negative and significant in specifications (2) and (3), while the variables *TotalStocks* and *YearStocks* are not significant in the specifications. These findings tend to justify grants of stock-options to managers in the aim of enhancing managerial performance. Grants of stocks are useless in comparison, as they do not provide incentives to favor managerial performance. As a consequence, we provide economic justifications for the recent expansion of stock options granted to managers.

Finally, we observe that *Delta* and *Vega* have opposite effects on managerial performance. That is, *Vega* favors performance, which means that greater incentives to invest in risky projects benefits to performance. However a greater *Delta* hampers performance, supporting the view that stronger incentives provided by stock options are prejudicial to performance. This result is counter-intuitive but might come from the fact that greater *Delta* incites managers to take lower risk, as their portfolio is particularly sensitive to the changes in stock price and already well-valuated since high Delta stock-options are by definition deep in the money options, with high intrinsic value.[5]

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[5] By the way, the deep out of the money stock-options do not give either incentives to CEOs, since the expected pay-off from these options is zero (zero intrinsic value and time value is near zero) and the sensibility of these options to underlying price changes is very low (delta near zero). Stock-option repricings, which frequently occur when such stock-options are out of the money, can then be

Regarding the control variables, we observe a positive and significant link between *Leverage* and managerial performance. This result should be related to Weill (2003), investigating the relationship between leverage on firm performance, also measured with frontier efficiency techniques, in France, Germany, and Italy. He found that this link varies across countries, according to the institutional environment, and also observes a positive link similar to ours in two of the three analyzed countries. Such positive influence results from the signaling role of debt to solve adverse selection problems between firms and lenders, and from the binding nature of debt raising the pressure on managers to perform.

As expected, we point out a positive relationship between a good *Rating*, assessing the credit quality of the firm, and a good managerial performance. The share of current liabilities in total liabilities, *CurrentLiabilities*, is also positively related to managerial performance, which can be explained by the fact that short-term debt has a more binding role than long-term debt in terms of enhanced pressures on managers to perform.

The positive and significant impact of the number of shareholders, *Shareholders*, on managerial performance is in accordance with the reduction in autonomy for managers – and consequently in their entrenchment possibilities – led by a larger number of shareholders. Finally, the number of board meetings during the year (*BoardMeetings*) and the recent dismission of a CEO (*Dismissed*) are not significant.

Therefore, our main findings support the "optimal contracting approach" in accordance with Murphy (1986), according to which executive compensation would be designed to favor managerial performance. Indeed we find that annual salary, annual bonus, and option grants contribute to enhance managerial performance. Our results are however a little more contrasted than those which could have been expected following the use of compensation to align the incentives of executives with the interests of shareholders. Indeed, while we observe some positive influence for option grant, bonus, and salary, all components which could have been designed to align these incentives, we do not observe a positive impact of stocks on performance. This qualifies the incentive effect of the ownership of stocks by managers.

Our conclusion is thus in contradiction with the view of Bebchuk and Fried (2003, 2004) according to which executive compensation would not exert an impact

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explained in the same sense: to give the CEO more incentives without another stock-options' grant, changing (lowering) the strike price is a convenient way to increase the *Delta* of these stock-options.

on managerial performance. That is, this view expects no positive link between CEO compensation and managerial performance, as manager's pay arrangements would be shaped by managerial power.

As a consequence, our findings provide support for raising CEO compensation to enhance managerial performance. Robustness tests are however needed to confirm this main conclusion.

4.2. Robustness checks

We perform several robustness checks to test the relevance of our main findings. In all robustness tests, we display results from the model specification with the breakdown of executive compensation including *YearStocks* and *YearOptions*. This is our benchmark specification.

First, we investigate the possibility of reverse causality. Indeed, while we test the impact of CEO compensation on managerial performance, one might consider that managerial performance may influence CEO compensation. Such relationship is not obvious as our measure of firm performance is technical efficiency, which considers the ability of a firm to produce the maximal output. In other words, profitability measures of performance are very likely to influence compensation components such as bonus, owing to the scheme incentives in connection with profitability. However technical efficiency scores are not directly related to CEO compensation.

In order to tackle this issue, we re-estimate the model by replacing compensation of the year by compensation of the previous year. That is to say we now investigate whether compensation of year (t-1) influences performance of year (t). This estimation is displayed in table 3. Most compensation components still have the same coefficients than in the benchmark estimation. As such, we observe that coefficients for all cash components (*Salary*, *Bonus*, *LTIP*) have the same sign and significance. As *Salary* and *Bonus* still have negative and significant coefficients, this finding therefore supports the fact that the causality is undoubtedly from compensation to managerial performance.

Furthermore coefficients of *Delta* and *Vega* keep the same signs, respectively positive and negative ones. Differences can however be pointed out for *YearOptions* and *YearStocks*. The coefficient for *YearOptions* remains negative but lacks significance. On the other hand, the coefficient for *YearStocks* remains positive but gains significance. Consequently, these findings suggest ambiguous causality between compensation through option grants and managerial performance. Such result can be explained by the fact that stock options are related to firm performance, even if we measure performance through cost measures and not profit measures. Regarding *YearStocks*, it may mean that, among the opposite effects of the ownership of shares for managers, the prejudicial ones prevail.

This first robustness check leads therefore to the conclusion that causality is clearly from compensation to performance for cash components and some stock components, while it is ambiguous for options grants and stocks grants.

Second, we are also concerned that our results may be contingent on the set of control variables. To this end, we test the findings with alternative sets of control variables. Our estimations contained two sets of control variables, one for corporate governance aspects (*Shareholders*, *BoardMeetings*, *Dismissed*) and one for industry-related factors (*Leverage*, *Rating*, *CurrentLiabilities*). We then re-estimate the model with three specifications: without all control variables, with the set of control variables for corporate governance aspects only, and with the set of industry-related factors only.

The estimations with these alternative sets of control variables are presented in table 4. In a nutshell, most of our findings are robust to the specification of the set of control variables. Hence the sign and the significance of the compensation variables are not affected, with one exception concerning *LTIP*. This variable has always a negative coefficient, but it is only significant when industry-related factors are dropped. Therefore, we can conclude that our main findings are robust to the choice of control variables.

Third, we allow for nonlinearities in the relationship between compensation components and managerial performance. Our findings suggest that several compensation components (salary, bonus, and option grants) should be increased in order to enhance managerial performance. We must however check whether the relation between these compensation components and managerial performance is U-shaped. It might notably be the case that an optimal level for salary or bonus exists.

The model is consequently re-estimated by adding squares of compensation components to the set of explanatory variables of inefficiency. Results are displayed in table 5. Components *LTIP* and *YearStocks* remain not significant. We also observe that the inclusion of the square of *YearOptions* leads to the non-significance of both variables taking into account this component, which may come from collinearity between these variables.

However a striking finding is the positive and significant coefficients for the squares of *Salary* and *Bonus*, while the coefficients for *Salary* and *Bonus* remain significantly negative. This suggests qualifying the view that the increase of the cash components of compensation fosters managerial performance. Indeed there exist optimal levels for salary and bonus, which are respectively USD 1.9m and 13.4m. Therefore the optimal salary represents about 3 times the mean salary observed for our sample (USD 625.3m), but is below the maximal value observed (USD 3,654.8m). Similarly the optimal bonus is largely above the mean bonus in our sample (USD 574.7), but is exceeded by some observations as the maximum bonus is USD 16,500m.

As a consequence, we do not support the view that salary and bonus for CEOs should be enhanced without limits for performance reasons. A ceiling might be implemented for these compensation components. Nevertheless, our findings suggest that cash compensation should be increased for many companies to favor firm performance.

To sum it up, robustness checks confirm the beneficial impact of salary and bonus on managerial performance, but they show the existence of an optimal level over which managerial performance would be hampered by increases in cash compensation. Moreover they rather support the positive impact of the ownership of stock options on managerial performance even if they show an ambiguous causality between these both dimensions.

5. Concluding remarks

The research presented here has provided new evidence on the relationship between CEO compensation and managerial performance. We use frontier efficiency scores to measure performance to evaluate this issue on an extensive dataset including information on all components of compensation on a large panel of US public firms.

We find that greater CEO compensation is associated with greater managerial performance. However the impact of CEO compensation on managerial performance differs according to the investigated component of compensation. That is, the increases of salary, annual bonus, or the option grants contribute to enhance managerial performance, while the stock grants are worthless.

Our findings do not however support the view of unlimited increases in CEO compensation, as we observe the existence of an optimal level for salary and for bonus over which managerial performance could fall. As these optimal levels are far beyond the mean values for salary and bonus, we nonetheless suggest that cash compensation could be enhanced to favor managerial performance.

In the debate on the role of executive compensation to address the agency problems in the firm, our results tend to support the "optimal contracting approach" according to which CEO compensation provides incentives for managerial performance. We therefore do not corroborate the view of Bebchuk and Fried (2003, 2004) considering executive compensation as the result of the degree of managerial power.

The normative implications of our findings are therefore that CEO compensation scheme can be designed to favor managerial performance. Optimal compensation should however take into account the differentiated impact of compensation components and the existence of an optimal level for some components. Under these limits, our findings tend to support the use of option grants to favor managerial performance and to provide some qualified economic justifications for high levels of CEO salary and bonus.

This first glance at the impact of CEO compensation on managerial performance leaves some questions unsolved. Notably, one can wonder whether similar findings can be observed in other countries than the US in which tax issues, compensation practices, corporate governance practices in the decision of CEO compensation, and also tax issues for compensation components, may be different. This opens avenues for further research.

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Appendix A. Description of variables

Variable	Description
	Variables for efficiency scores
Production	Net sales
Labor (L)	Number of employees
Physical capital (K)	Amortization and depreciation expenses
	Compensation variables
TotalCompensation	All components of compensation received during the year (=Salary +Bonus +LTIP +YearShares +YearOptions)
Salary	Fixed annual salary
Bonus	Annual bonus
LTIP	Grants (employee stock-options and/or restricted shares) subject to a “vesting period”, provided in a Long Term Incentive Plan (LTIP) framework
Delta	Partial derivative of the Black-Scholes stock option value to the value of the underlying stock. Measures the incentives given by stock options to CEOs.
Vega	Partial derivative of the Black-Scholes stock option value to the volatility of the underlying stock. Measures the incentives for managers to invest in risky projects.
TotalStocks	Total stocks holdings
TotalOptions	Total stock options holdings
YearStocks	Stock grants during the year
YearOptions	Option grants during the year
	Control variables
Shareholders	Log of the number of registred shareholders in thousands
BoardMeetings	Number of board meetings during the year
Dismissed	Dummy variable equal to one if the CEO has been dismissed from the firm during the period of study, and zero else
Leverage	Ratio of total debt to total assets
Rating	Standard and Poor’s long-term credit rating scores, from 1 (AAA) to 6 (D)
CurrentLiabilities	Ratio of short-term liabilities to total liabilities

Appendix B. CEO portfolios' computations

A summary of our variables' definitions and calculations related to the stock-based compensation of each CEO can be found in this appendix. In what follows, we specially insist on the proxies chosen for managerial ownership and more broadly managerial incentives.

We do know the number of ESO granted each year to each CEO included in the database, as well as the strike, the vesting period and other specific features of these employee stock options, such as stock volatility and so on. For a given year, it's in consequence quite simple to calculate the value of these grants, by simply using the Black-Scholes formula (with the Merton addition for dividends). It's also straightforward to obtain delta for these grants.

Since Compustat Execucomp details the yearly number of exercised stock-options, one can, under the hypothesis that the exercised stock-options are always the eldest in-the-money options[6], also find the annual cash flow provided by the stock-option exercises to the CEO.

The point here is to obtain the total value of stock-options held by a CEO. It's easy to obtain from the yearly numbers of option grants and exercised stock-options the net increase or decrease of the number of stock-option ownership. And we know the initial total value of stock-options already owned by the CEO when he is for the first time present in our database (the initial stock, to put it another way), computed by Compustat with the Black and Scholes method. We also know the number of such options which are in-the-money. But additional information, especially strike, is missing for these options.

An approximation is thus made to take account of these "old" stock-options, following Habib and Ljungqvist (2005). We estimate for the first year of inclusion of a given CEO in our sample an average strike price, K, for the stock-options he already holds. This estimation relies upon the stock price P the total value of stock-options V and the number of in-the-money stock-options N. Given the following equality: $V = N \times (P - S)$, one can extract the average strike, K, of all 'old' stock-options. We therefore assume that all out-of-the-money options have no value at all, that is, no time value. Another approximation is made regarding the vesting period of these options. With no information at all on the subject, we allot to these options the average vesting period in our sample (4 years).

Once these computations made, one can obtain the dollar value of the CEO option-holdings, CEO option-holdings sensitivity to market value of firm (what we call the global delta), since each grant's delta is the partial derivative of the option value with respect to the underlying asset price. The global delta is simply the weighted average of these deltas. Vega is

[6] We here follow Hall and Liebman (1998). It's the only way given the data available to obtain a yearly average exercise price for exercised stock-options.

computed in the same way, as the partial derivative of the option value with respect to the volatility of the underlying asset.

Turning to managerial ownership proxies, we closely follow the variables definitions of Habib and Ljungqvist (2005), focusing our attention to the CEO. We simply use the weight of the managerial ownership, in percentage or in value (using the end-of-year stock value for the valuation). Once again, two distinct approaches can be followed, the first one focused on the annual grant of restricted stocks (flow approach) and the other related to the CEO portfolio of restricted stocks (stock approach). We do have enough information to compute both proxies and to use them alternatively in our regressions.

Table 1
Descriptive statistics

The table below provides descriptive statistics for all variables used in the estimations. Definition of variables appears in the Appendix A. Production and physical capital are in thousand dollars. Compensation variables are in thousand dollars, with the exception of Delta and Vega. *CurrentLiabilities* and *Leverage* are in percentage. *Shareholders* is the log of the number of shareholders in thousands. *Dismissed* is a dummy variable. *Rating* is a discrete variable from 0 to 5.

	Mean	Standard deviation	Minimum	Maximum
	Variables for efficiency scores			
Production	1,573,409.2	3,781.0	64,457.1	99,807,638.8
Labor (L)	8,390	3,865	243	480,103
Physical capital (K)	78,492.3	4,271.6	1,420.5	13,426,692.7
	Compensation variables			
Totcomp	4,629.0	9,250.3	160.5	297,000.0
Salary	625.3	293.6	20.8	3,654.8
Bonus	574.7	790.2	0	16,500.0
LTIP	162.9	658.3	0	15,105.0
Delta	0.7	0.2	0	1
Vega	0.4	0.2	0	1
TotalStocks	57,653.2	612,000.0	0	37,300,000.0
TotalOptions	14,052.7	79,834.2	0	3,430,000.0
YearStocks	291.4	1,698.0	0	66,991.0
YearOptions	2,790.9	8,301.0	0	295,000.0
	Control variables			
Shareholders	1.9	1.7	-3.1	9.9
BoardMeetings	7.3	2.8	1	26
Dismissed	0.1	0.2	0	1
Leverage	0.6	0.2	0.1	1
Rating	4.1	1.7	1	6
CurrentLiabilities	0.5	0.2	0.1	1

Table 2
Empirical results

Each column presents a stochastic frontier model estimated using maximum likelihood. Definitions of variables appear in the Appendix A. Standard errors are displayed in parentheses. *, **, *** denote an estimate significantly different from 0 at the 10%, 5% or 1% level. Dummy variables for industries and years are included in the regressions but are not reported.

	(1)			(2)			(3)		
Intercept	1.130	***	(0.051)	1.394	***	(0.057)	1.382	***	(0.058)
Ln L	0.250	***	(0.022)	0.222	***	(0.022)	0.220	***	(0.022)
Ln K	0.541	***	(0.026)	0.481	***	(0.026)	0.481	***	(0.026)
(Ln L)²	-0.047	***	(0.005)	-0.041	***	(0.004)	-0.041	***	(0.004)
(Ln K)²	-0.033	***	(0.004)	-0.027	***	(0.004)	-0.027	***	(0.004)
(Ln L) (Ln K)	0.087	***	(0.008)	0.080	***	(0.008)	0.081	***	(0.008)
Intercept	4.857	***	(0.112)	5.196	***	(0.106)	5.183	***	(0.106)
TotalCompensation	-0.005	***	(0.001)	-			-		
Salary	-			-0.375	***	(0.034)	-0.372	***	(0.035)
Bonus	-			-0.103	***	(0.015)	-0.109	***	(0.015)
LTIP	-			-0.006		(0.024)	-0.014		(0.028)
Delta	-			0.213	***	(0.034)	0.221	***	(0.034)
Vega	-			-0.403	***	(0.049)	-0.410	***	(0.048)
TotalStocks	-			-0.001		(0.016)	-		
TotalOptions	-			-0.389	***	(0.128)	-		
YearStocks	-			-			4.361		(3.599)
YearOptions	-			-			-2.535	***	(0.795)
Shareholders	-0.046	***	(0.004)	-0.030	***	(0.004)	-0.031	***	(0.004)
BoardMeetings	-0.002		(0.002)	-0.004	**	(0.002)	-0.004	**	(0.002)
Dismissed	0.019		(0.019)	-0.001		(0.019)	-0.003		(0.019)
Leverage	-0.774	***	(0.042)	-0.709	***	(0.038)	-0.711	***	(0.038)
Rating	0.030	***	(0.004)	0.015	***	(0.004)	0.014	***	(0.004)
CurrentLiabilities	-0.725	***	(0.033)	-0.654	***	(0.028)	-0.657	***	(0.029)
Log-likelihood	-1094.787			-865.908			-867.520		
Number of obs.	5224			5224			5224		

Table 3
Robustness checks: Results with lagged values for explanatory variables

Each column presents a stochastic frontier model estimated using maximum likelihood. Definitions of variables appear in the Appendix A. Standard errors are displayed in parentheses. *, **, *** denote an estimate significantly different from 0 at the 10%, 5% or 1% level. Dummy variables for industries and years are included in the regressions but are not reported.

	Coef.		Std. Err.
Intercept	5.069	***	(0.121)
Ln L	0.191	***	(0.028)
Ln K	0.565	***	(0.033)
(Ln L)²	-0.043	***	(0.005)
(Ln K)²	-0.038	***	(0.005)
(Ln L) (Ln K)	0.090	***	(0.010)
Intercept	1.565	***	(0.064)
Salary(t-1)	-0.332	***	(0.039)
Bonus(t-1)	-0.100	***	(0.016)
LTIP(t-1)	-0.004		(0.018)
Delta(t-1)	0.182	***	(0.040)
Vega(t-1)	-0.399	***	(0.053)
YearStocks(t-1)	12.760	**	(6.394)
YearOptions(t-1)	-1.031		(1.099)
Shareholders(t-1)	-0.033	***	(0.005)
BoardMeetings(t-1)	-0.004	**	(0.002)
Dismissed(t-1)	-0.220		(0.162)
Leverage(t-1)	-0.815	***	(0.051)
Rating(t-1)	-0.008	*	(0.004)
Currentliabilities(t-1)	-0.714	***	(0.036)
Log-likelihood	-614.907		
Number of obs.	3,733		

Table 4
Robustness checks: Results with alternative sets of control variables

Each column presents a stochastic frontier model estimated using maximum likelihood. Definitions of variables appear in the Appendix A. Standard errors are displayed in parentheses. *, **, *** denote an estimate significantly different from 0 at the 10%, 5% or 1% level. Dummy variables for industries and years are included in the regressions but are not reported. Variables are for year t except where indicated.

	(1)	(2)	(3)
Intercept	5.245 *** (0.108)	5.090 *** (0.105)	5.121*** (0.107)
Ln L	0.170 *** (0.023)	0.228 *** (0.022)	0.172*** (0.023)
Ln K	0.467 *** (0.027)	0.502 *** (0.025)	0.488*** (0.027)
$(\text{Ln L})^2$	- 0.050 *** (0.005)	- 0.040 *** (0.004)	- 0.047*** (0.005)
$(\text{Ln K})^2$	- 0.034 *** (0.004)	- 0.027 *** (0.004)	- 0.034*** (0.004)
(Ln L) (Ln K)	0.105 *** (0.008)	0.078 *** (0.008)	0.102*** (0.008)
Intercept	0.800 *** (0.047)	-	0.612*** (0.042)
Salary	- 0.526 *** (0.042)	- 0.405 *** (0.034)	- 0.600*** (0.046)
Bonus	- 0.194 *** (0.022)	- 0.105 *** (0.014)	- 0.222*** (0.024)
LTIP	- 0.106 *** (0.037)	0.001 (0.016)	- 0.128*** (0.042)
Delta	0.236 *** (0.036)	0.326 *** (0.033)	0.358*** (0.037)
Vega	- 0.441 *** (0.058)	- 0.429 *** (0.048)	- 0.451*** (0.065)
YearStocks	2.295 (6.099)	3.532 (3.790)	1.135 (7.311)
YearOptions	- 3.326 *** (1.042)	- 2.944 *** (0.793)	- 4.420*** (1.340)
Shareholders	- 0.036 *** (0.005)	-	-
BoardMeetings	- 0.006 *** (0.002)	-	-
Dismissed	- 0.206 (0.168)	-	-
Leverage	-	- 0.707 *** (0.039)	-
Rating	-	- 0.011 *** (0.003)	-
CurrentLiabilities	-	- 0.672 *** (0.029)	-
Log-likelihood	-1189.426	-905.811	-1225.414
Number of obs.	5224	5224	5224

Table 5
Robustness checks: Tests for non-linearities

Each column presents a stochastic frontier model estimated using maximum likelihood. Definitions of variables appear in the Appendix A. Standard errors are displayed in parentheses. *, **, *** denote an estimate significantly different from 0 at the 10%, 5% or 1% level. Dummy variables for industries and years are included in the regressions but are not reported.

	Coef.		Std. Err.
Intercept	5.224	***	(0.109)
Ln L	0.215	***	(0.022)
Ln K	0.487	***	(0.025)
(Ln L)²	-0.041	***	(0.004)
(Ln K)²	-0.028	***	(0.004)
(Ln L) (Ln K)	0.082	***	(0.008)
Intercept	1.550	***	(0.061)
Salary	-0.586	***	(0.057)
Salary²	0.154	***	(0.029)
Bonus	-0.107	***	(0.015)
Bonus²	0.004	**	(0.002)
LTIP	-0.014		(0.020)
LTIP²	0.003		(0.002)
Delta	0.221	***	(0.334)
Vega	-0.436	***	(0.045)
YearStocks	4.844		(6.101)
YearStocks²	-42.767		(128.973)
YearOptions	-0.290		(1.629)
YearOptions²	-28.467		(20.362)
Shareholders	-0.032	***	(0.004)
BoardMeetings	-0.003	*	(0.002)
Dismissed	-0.187		(0.140)
Leverage	-0.664	***	(0.039)
Rating	-0.011	***	(0.003)
CurrentLiabilities	-0.653	***	(0.028)
Log-likelihood	-852.691		
Number of obs.	5224		

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