Executive Compensation and Corporate Production Efficiency: A Stochastic Frontier Approach

H. Young Baek
Nova Southeastern University

José A. Pagán
The University of Texas-Pan American

This study uses 1992-1998 data on the S&P 1500 firms to examine the relationship between executive pay and technical productive efficiency. The parameters of a stochastic frontier production function are estimated simultaneously with the firm-specific inefficiency effects in a panel framework. After controlling for industry and firm size, the level of CEO total compensation is positively related to technical efficiency. Annual salary and the value of restricted stocks and stock options as a percentage of total compensation, however, are both negatively related to technical efficiency. The number of years as a company CEO is also negatively related to technical efficiency. In all, the results suggest that both the level and the structure of CEO compensation are important factors when assessing the technical efficiency and economic performance of firms.

Introduction

Over the last decade, substantial increases in top executive compensation in medium and large firms have generated concern—is high executive pay connected to firm performance? Over the 1990-1996 period the average compensation to S&P 500 executives increased around 150 percent (Hallock and Murphy, 1999). The portion of total pay based on stocks and options also increased from 30 percent to 50 percent during the same period.

Studies on the impact of executive pay on firm performance have found mixed results depending on the definition of performance employed and the data analyzed.[1] Moreover, researchers have been more concerned with the links between executive

[1] Hallock and Murphy (1999) and Murphy (1999) provide reviews on executive compensation research, and Abowd and Kaplan (1999) list further areas of inquiry.

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pay and short-term financial performance than with economic efficiency. Analyzing the connection between executive pay and economic efficiency is particularly important because economic-based efficiency measures are reasonable indicators of the long-term health and prospects of a given firm.

The purpose of this study is to analyze the impact of the level and structure of executive compensation on the technical efficiency of corporations using panel data for a large number of U.S. firms. A firm can be characterized as technically inefficient if it is not able to reach maximum output given its available resources and technology. The technical efficiency/compensation linkages are analyzed by estimating a stochastic frontier model where the parameters of the production function are estimated simultaneously with the technical efficiency effects (Battese and Coelli, 1995). The model is estimated using data from the Standard & Poor's (S&P) *ExecuComp* database for the 1992-1998 period.

The empirical analysis suggests that, after controlling for firm size and industry, the level of CEO total compensation is positively related to technical efficiency. Yearly salary as a percentage of total compensation, however, is negatively related to production efficiency. The values of restricted stocks and stock options granted in a given year also are negatively related to production efficiency. Bonuses and management stock ownership seem to be positively related to firm technical efficiency, but these relationships are statistically insignificant. The number of years as a company CEO is negatively related to technical efficiency; thus, CEOs' marginal productivity or career concerns seem to diminish as retirement approaches.

Compensation and Performance

A firm is an economic organization in which some transactions are internalized (Coase, 1937). It is different from other contracts across the market because it has "the centralized contractual agent" that characterizes team production (Alchian and Demsetz, 1972). According to Jensen and Meckling (1976), the "negligence and profusion" of directors in joint-stock companies are documented as early as in 1776 by Adam Smith and later by Berle and Means (1932). Devices to prevent managers from reaching sub-optimal decisions include monitoring by a board of directors (Fama and Jensen, 1983) and outside large shareholders (Shleifer and Vishny, 1986), as well as the forces from corporate control markets (Manne, 1965; Jensen and Ruback, 1983) and managerial labor markets (Fama, 1980). A more direct way to motivate firm managers to work on behalf of their shareholders is to bond their wealth to that of the shareholders through management equity ownership (Jensen and Meckling, 1976) or performance-based compensation (Jensen and Murphy, 1990).

The escalating cost of executive compensation packages has been of interest to researchers during the last decade. The median top executive compensation in S&P 500 companies has increased from a little over \$1 million in 1990 to around \$2.5 million in 1996 (Hallock and Murphy, 1999). Moreover, the portion of total pay based on stocks and options also has increased from 30 percent to 50 percent during the same period. But does higher or better pay increase firm performance? The answer depends on how firm performance is defined. Under different assumptions, performance may mean the value of the firm, stockholders' return, accounting income, or revenue.

Some difficulties exist in empirically examining whether higher pay and/or higher pay-performance sensitivity leads to a higher stock return performance. Because information on the level and structure of top management compensation is publicly available, the efficient capital market hypothesis implies that this information already has been incorporated into the current stock price. The effect of improved management incentives will be manifested in the stock price upon the announcement of such events.

Although studies such as Abowd (1990) find positive abnormal returns (AR) around performance-based pay adoption, two issues also arise with event study analyses. First, the identification of event dates is ambiguous. Second, even if one pinpoints the exact event date and finds a positive abnormal return, the finding is consistent with two different hypotheses. A positive abnormal return may mean some reduction in agency costs through better alignment of incentives, but it also may mean that top executives are able to time the events or the announcements of "good" news (Yermack, 1997).

Some researchers have attempted to relate managerial stock ownership and compensation to Tobin's Q ratio, defined as the market value of the firm divided by the replacement costs of the assets. Morck, Shleifer, and Vishny (1988) find that Q increases with managerial ownership between 0 percent and 5 percent, decreases within the 5 percent to 25 percent range, and again increases after the 25 percent level. McConnell and Servaes (1990) find that the firm value is maximized when insider ownership is around 35 percent to 45 percent.

Cole and Mehran (1998) argue that removal of ownership restrictions enables the firm to choose an optimal ownership structure. For a sample of 94 thrift institutions that converted from mutual to stock ownership during 1983-1987, they find significant increases in percentage ownership by the largest inside shareholder, institutional investors, employee stock ownership plan (ESOP) participants, and stock returns from pre (year –3 to –1) to post (year 1 to 3) period. For firms that experience increases in inside ownership above (below) the median level, raw and industry-adjusted stock return increases are significantly positive (negative), and the difference is statistically significant. For firms that experience above-median ESOP ownership increase, stock return change is significantly negative.

Direct investigations of the relationship between pay and Tobin's Q ratio also exist. Using data for 500 executives from 75 of the largest U.S. manufacturing firms over the 1964-1981 period, Murphy (1985) finds a statistically significant relationship (albeit small) between total compensation level and stock performance. The result indicates that a firm realizing a 10 percent rate of return will increase the total remuneration of an executive by 2.1 percent. Gibbons and Murphy (1990) also find that CEO salary and bonus is positively related to stock return, but negatively related to industry performance. Jensen and Murphy (1990) also find the relationship between executive wealth change and shareholder wealth change statistically significant but economically insignificant.

In a comprehensive study of firm performance using 1979-1980 compensation data for 153 randomly selected manufacturing firms, Mehran (1995) finds that performance, as measured by Tobin's Q and return on assets (ROA), is positively related to the proportion of equity-based compensation, management ownership of stocks and options, and research and development expenses over sales. Core, Holthausen, and Larcker (1999) find for 205 public U.S. firms during 1982-1984 that the average ROA (one, three, or five years) and stock returns are negatively related to the "predicted excess compensation," which is controlled by stock ownership and board of directors' variables. Cho (1998) and Himmelberg, Hubbard, and Palia (1999), however, find little evidence that management ownership affects performance after controlling for endogeneity between ownership and performance.

Few studies have analyzed the impact of executive pay structure on corporate technical efficiency. Murphy (1985) studies stock performance using only the largest firms and does not account for managerial stock ownership. Mehran (1995) uses Tobin's Q to measure performance, but Q may represent the growth opportunity of a firm rather than current year's performance. The return on assets measure used by Mehran (1995), Core, Holthousen, and Larcker (1999), and Ke, Petroni, and Safieddine (1999) is often subject to management manipulation. Thus, gaining a better understanding of the links between executive compensation and firm's productive efficiency is important to those interested in designing compensation packages that lead to better firm performance in both the short and the long run.

Managers with equity-based compensation may increase the short-term stock performance in many ways: 1) increased productive efficiency, 2) reduced expenses such as wages, interest expenses, R&D, or taxes, 3) short-horizon investments at the expense of long-term stock performance, 4) riskier investments at the expense of bondholders' wealth, and 5) earnings manipulation.

Previous studies suggest that U.S. firms use at least some of the above-mentioned mechanisms. Dechow and Sloan (1991) find that CEOs reduce discretionary expenditures such R&D and advertising in their last years to boost accounting earnings and bonus. Narayanan (1996) argues that all-cash (all-stock) management compensation leads to under- (over-) investment. Amihud and Lev (1981) suggest that managers want a compensation plan that lowers personal risk and they may engage in risk-reducing activities, DeFusco, Johnson, and Zorn (1990) find that, around stock option plan adoptions, stock volatility increases, shareholders experience wealth gains, and bondholders experience losses.

In all, some policy changes designed to improve short-term stock performance including executive compensation may decrease technical efficiency and consequently jeopardize the long-term value of the firm. This study attempts to measure the production efficiency, applying a stochastic frontier production function to the sample of S&P 1500 firms, and to analyze the cross-sectional relationship between level and structure of top management compensation and production efficiency. This model allows for the estimation of firm effects, which can be useful to assess the role of executive compensation on technical efficiency/inefficiency.

A Stochastic Frontier Model with Inefficiency Effects

To measure the technical productive efficiency of firms, we use the stochastic frontier production model proposed by Battese and Coelli (1995). Although the stochastic frontier models traditionally have been in production economics, they also have been used to study financial issues. For example, Hunt-McCool, Koh, and Francis (1996) use the stochastic frontier model to measure the degree of initial public offering (IPO) underpricing.

The advantage of using this technique is that it allows us to estimate inefficiency in production while at the same time taking into account random noise. Essentially, the method is simply a regression with two error terms: One term is the typical error included in regression equations, and the second term captures inefficiency. Battese and Coelli (1995) extend this model to panel data and also derive a version of the model that can relate firm inefficiency to other variables. In our case, we argue that production efficiency can be related to the compensation structure of the firm.

The method allows us to learn whether the compensation structure of a firm is statistically related to the technical efficiency of the firm. This is important because technical efficiency is related to good productive practices and the efficient use of resources and, as such, it can be linked to long-term profitability. Thus, the advantage of using the stochastic frontier production approach is that it allows us to look at long-term rather than short-term profitability.

We begin by specifying a production frontier that has output as a function of inputs and an inefficiency term. This inefficiency term captures how far a firm is from its potential maximum production. A second equation specifies inefficiency as a function of a set of variables related to executive compensation and other firm-specific variables related to technical efficiency/inefficiency. Moreover, a stochastic error term in the production function allows us to get a measure of inefficiency net of noise.[2]

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[2] The Battese and Coelli (1995) model is a panel data extension of the models originally proposed by Kumbhakar, Ghosh, and McGuckin (1991), Reifschneider and Stevenson (1991), and Huang and Liu (1994).

Using a translog specification, the production frontier for firm i in year t is given by:

$$\ln Q_{it} = \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3(\ln K_{it})^2 + \beta_4(\ln L_{it})^2 + \beta_5 \ln K \times \ln L_{it} + \eta' I_{it} + v_{it} - u_{it}, \quad (1)$$

where:

i = 1, 2, … , N;
t = 1, 2, … , T;
$\ln Q_{it}$ = The log of the dollar value of production for firm i in year t;
$\ln K_{it}$ = The log of the value of fixed assets; and
$\ln L_{it}$ = The log of the total number of employees.

The dollar value of production is estimated as the sum of sales and inventory change during a year. In addition, a vector of industry dummies I_{it} is added to capture differences in the production technology across 28 industry categories.[3] The βs are the parameters to be estimated, v_{it} is a normally distributed error term with a zero mean and variance σ_v^2, and u_{it} is a random variable that has a truncated normal distribution with mean μ_u and variance σ_u^2.

To analyze possible sources of technical inefficiency, the inefficiency effect, u_{it}, in the stochastic frontier function can be specified as:

$$u_{it} = \theta' Z_{it} + w_{it}, \quad (2)$$

where:

Z_{it} = A vector of variables related to technical inefficiency for firm i in year t;
θ = The vector of inefficiency parameters to be estimated; and
w_{it} = An error term that follows a normal distribution but has a variable truncation point at $-\theta' Z_{it}$.

Z_{it} includes the variables that capture the executive compensation structure of firms as well as other control variables.

The parameters in equations (1) and (2) are estimated jointly by the maximum likelihood method (Battese and Coelli, 1995). The likelihood function is maximized in terms of the variance parameters $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2/\sigma^2$, as suggested by Battese and Corra (1977).[4] The general idea here is that by estimating equation (2) we will be able to point out what facet of the compensation package is directly related to technical efficiency (or lack of it).

Technical efficiency in this model is given by:

$$TE_i = \exp(u_{it}) = \exp(-\theta' Z_{it} - w_{it}), \quad (3)$$

which can be predicted by:

$$E[\exp(u_{it})|\, (v_{it} - u_{it})] = [\exp(-\mu^*_{it} + .5\, \sigma^{*2})] \times [\Phi(\mu^*_{it}/\sigma^* - \sigma^*)/\Phi(\mu^*_{it}/\sigma^*)], \quad (4)$$

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[3] The model also is estimated using eight major industry categories (i.e., manufacturing, mining, construction, transportation, utility, trade, banking and services), but the results do not substantially change.

[4] Battese and Coelli (1993) present the derivation of the log-likelihood function for this model.

where $\mu^*_{it} = [\sigma_v^2(\theta' Z_{it}) - \sigma_u^2(w_{it})]/(\sigma_v^2 + \sigma_u^2)$ and $\sigma^{*2} = \sigma_v^2\sigma_u^2/(\sigma_v^2 + \sigma_u^2)$ (Kumbhakar and Lovell, 2000).

Data

To estimate the model presented above, we use data from the Standard & Poor's *ExecuComp* database, which includes executive compensation information for S&P 1500 companies over the period of 1992 to 1998. By combining S&P 500, Mid-Cap 400, and Small-Cap 600, the S&P Super Composite 1500 Index represents 87 percent of the total U.S. equity market capitalization. In each year we chose the chief executive officer (CEO) of each firm as the top executive. After deleting observations with missing values, our final sample consists of 1,030 firms and 4,620 firm-year observations.

To test the relationship between compensation level and structure and technical efficiency, we construct the following variables for the CEO of firm i in year t: dollar value of cash and non-cash base salary earned (SALARY), dollar value of bonus (BONUS), value of restricted stock granted (RSTOCK), the modified Black and Scholes (1973) value of stock options granted (OPTION), and the total compensation [comprising salary, bonus, restricted stock granted, stock options granted, long-term incentive plan payouts, and all other forms of compensation (TOTALCOMP)]. The log of total compensation is used as the level of compensation, and the components are expressed as a percent of total compensation. The percentage of the company's shares (excluding stock options) owned by the top manager (MGTOWN) is also included.

When managers with high (low) performance history generate high (low) wage offers, the external managerial labor markets induce managers with career concerns to make optimal decisions to maximize shareholder wealth (Fama, 1980). Internal promotion and acquisition of more control can also provide incentives to produce high output (Lazear and Rosen, 1981). Executive career concerns, external or internal, seem to diminish as the date of retirement gets closer. Dechow and Sloan (1991) find evidence that CEOs tend to reduce discretionary expenditures (such as research and development) and advertising expenses to increase accounting income and bonuses in their last years. To test the relationship between career concerns and production efficiency, we also include the number of years as a CEO in equation (2) (CEOYEARS).

Table 1 reports the descriptive statistics for the sample employed in estimating the stochastic frontier model. Mean production (Q: sales plus inventory changes) amounts to \$3,551.8 million, while its median value is \$1,184.6 million. Mean fixed assets (K) amounts to \$2,470.8 million, and the median number of employees (L) is 6,517 workers. As median values are larger than mean values of production (capital and labor) large firms in the S&P 500 index are more influential than middle- and small-sized firms in the Mid-Cap and Small-Cap indexes.

Table 1—Descriptive Statistics

	Mean	Std. Dev.	Min	Med	Max
Q: Sales + Inventory Change (1,000 $)	3,551,754	7,388,534	520	1,184,600	137,255,000
K: Fixed Assets (1,000 $)	2,470,789	4,911,223	2,110	603,753	49,375,000
L: Number of Employees (1,000)	18.619	42.810	0.02	6.517	910
TOTALCOMP (1,000 $)	3,051,758	10,798,370	0	1,614,850	655,448,000
SALARY / TOTALCOMP	0.3755	0.2401	0	0.3262	1
BONUS / TOTALCOMP	0.2002	0.1638	0	0.1834	0.9600
RSTOCK / TOTALCOMP	0.0429	0.1155	0	0	0.9900
OPTION / TOTALCOMP	0.2953	0.2760	0	0.2523	1
MGTOWN	2.9440%	7.0253%	0	0	54.70%
CEOYEARS	7.5885	7.4997	0	5	53

Number of firm-year observations is 4,620. Q denotes the level of production and is measured by sales plus inventory changes. K denotes capital and is measured by fixed assets. L denotes labor and is measured by the number of employees. TOTALCOMP denotes the total compensation comprising salary, bonus, restricted stock granted, stock options granted, long-term incentive plan payouts, and all other forms of compensation SALARY the dollar value of cash and non-cash base salary earned, BONUS the dollar value of bonus, RSTOCK the value of restricted stock granted, OPTION the modified Black and Scholes (1973) value of stock options granted, MGTOWN the percentage of the company's shares (excluding stock options) owned by the top manager, and CEOYEARS the number of years as a CEO.

We modify Lippert and Moore's (1995) industry classification scheme and produce the following dummy variables:

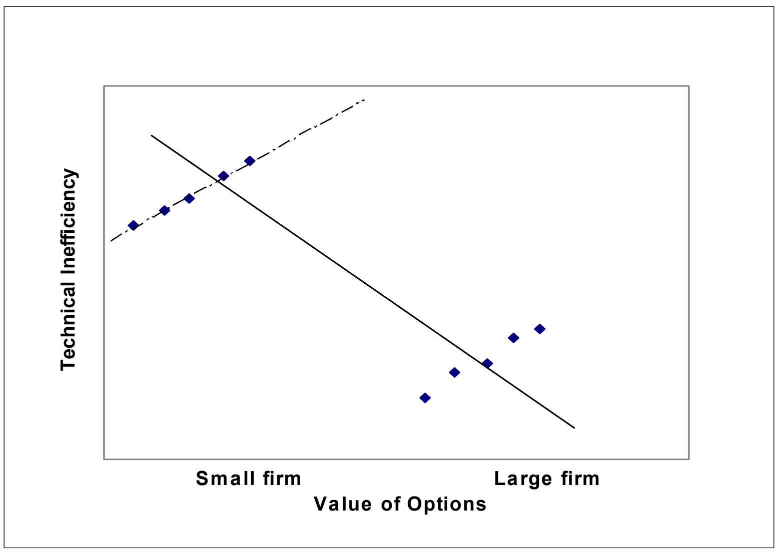
AERO-SHIP (SIC codes 3720-3829)	HOUSE (2840-2844)
AGRIculture-METAl (0-1099,1400-1499)	MACHINE (3510-3569, 3580-3652)
CARS (3711-3716)	MEDIC-Photo-other mfg (3841-3999)
CHEM (2800-2821)	PAINT (2851-2891)
COMMO (4812-4899)	PAPER (2600-2673)
COMPUTE (3570-3579)	PETRO (1220-1389)
CONSTRUC-Wood-Furn (1500-1799,2400-2599,3200-3299)	PUBLISH (2711-2780)
	REFINE (2911-2999)
DRUGS (2833-2839)	wholesale-RETAIL (5000-5999)
ELEC (3661-3699)	SOFTWARE (7370-7389)
ENTERTAI (7000-7369, 7400-7999)	STEEL (3300-3496)
FINANCE (6000-6799)	TEXTILE (2200-2399)
FOODTOBAco (2000-2199)	TIRES-leather (3011-3199)
HEALTH-Edu-Law (8000-9999)	TRANS (4011-4799)
	UTILITY (4911-4991).

The median value of the annual CEO compensation amounts to $1.6 million. On average, salary amounts to 37.6 percent of total compensation, followed by options granted (29.5 percent), bonus (20 percent), and others. CEOs own on average about 2.9 percent of the stock in the firms that they manage, and the mean tenure as a CEO is 7.6 years, with a median tenure of only five years. Twenty-eight industry classes are listed at the bottom of Table 1.

Before discussing the empirical results, it is important to point out a possible misspecification problem with panel data, as has been observed by Murphy (1985).

Suppose that, for a majority of the firms in the sample, production inefficiency is positively related to the value of newly granted options as a fraction of total compensation as illustrated in Figure 1. Suppose also that larger firms grant higher fraction of compensation as stock options and exhibit lower inefficiency. Then a cross-sectional regression would show a negative slope for an estimated relationship while the true relationship within firms is a positive one. Assuming the slopes are the same for all firms but intercepts are different, we add a dummy variable that indicates if a firm belongs to the S&P 500, Mid-Cap 400 (MID), or Small-Cap 600 (SMALL). Another dummy variable, EX, is included to capture whether the firm is not in a major S&P index during a specific year.

Figure 1—Options Granted and Inefficiency

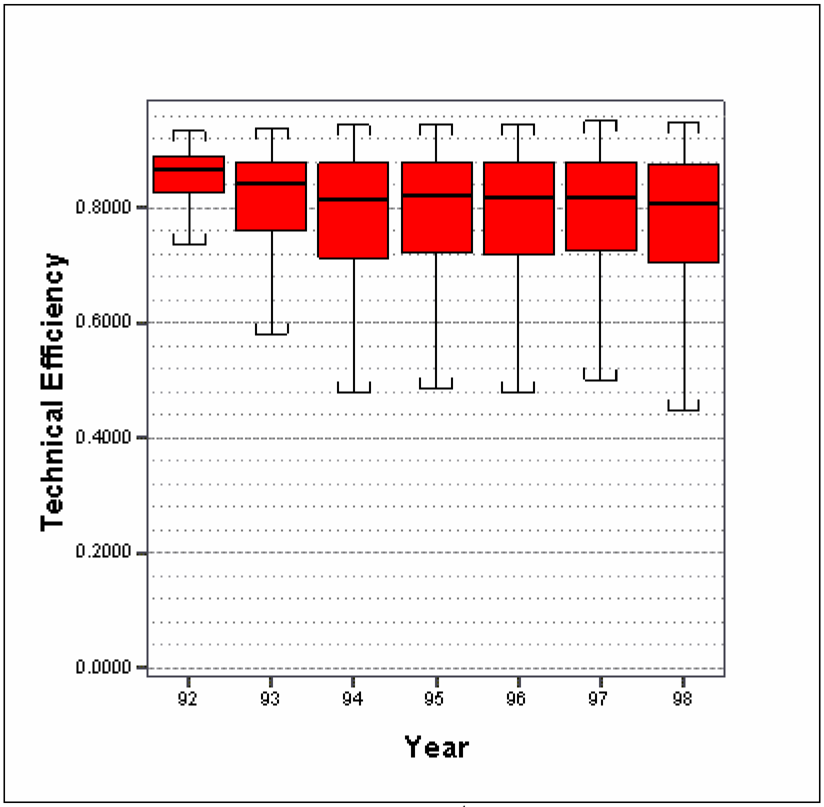


Empirical Results

Figures 2 and 3 present box and whiskers plots of technical efficiency by year and industry. The upper and lower sides of each box represent the 25th and 75 percentiles of the distribution of the technical efficiency scores for the given year (industry). Thus, the box includes half the data values. The middle line inside the box represents the median and the whiskers—which are the lines extending from each box—represent the distance to the smallest (bottom whisker) and largest (top whisker) observations that are located within one quartile from the box.[5] Figure 2 shows that the median technical efficiency score falls from 0.865 in 1992 to .815 in

[5] See Hair, Anderson, and Black (1998) for a discussion and application of this method.

Figure 2—Box and Whiskers Plot by Year

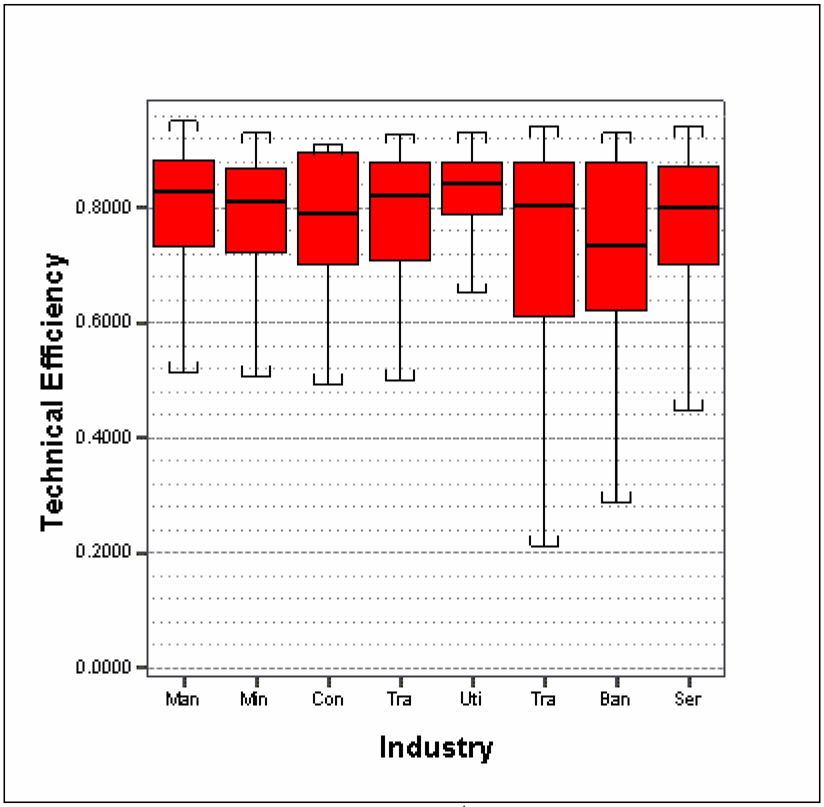


The upper and lower sides of each box represent the 25th and 75 percentiles of the distribution of the technical efficiency scores for the given year. Thus, the box includes half the data values. The middle line inside the box represents the median and the whiskers—which are the lines extending from each box—represent the distance to the smallest (bottom whisker) and largest (top whisker) observations that are located within one quartile from the box.

1994 and it remains within the 0.81-0.82 neighborhood throughout the rest of the 1990s. Note also that both the boxes and whiskers get larger from 1992 to 1994, but their size remains fairly constant from 1994 to 1998; that is, the spread of the distribution increases from 1992 to 1994 and then remains constant.

Using eight aggregate industries, Figure 3 shows that the median technical efficiency score during the 1992-1998 period was the highest for utilities (0.842) followed by firms in manufacturing (0.827), transportation (0.822), mining (0.809), trade (0.805), services (0.800), construction (.792) and banking (0.734). Note also that the spread of the technical efficiency scores is large in transportation and banking but small for utilities.

Figure 3—Box and Whiskers Plot by Industry



The upper and lower sides of each box represent the 25th and 75 percentiles of the distribution of the technical efficiency scores for the given industry. Thus, the box includes half the data values. The middle line inside the box represents the median and the whiskers—which are the lines extending from each box—represent the distance to the smallest (bottom whisker) and largest (top whisker) observations that are located within one quartile from the box.

Table 2 reports the results from estimating different specifications of the inefficiency effects equation.[6] Suffice it to say that the estimated parameters for the production functions have appropriate signs and are statistically significant. Also, there is evidence that the production technology varies across industries given the statistical significance of the industry dummy variables.

The estimated ratio of variances parameter, γ, takes values ranging from 0.68 and 0.76, and the parameters are all statistically significant. These results suggest that the inefficiency effects are likely to be important because most of the composite error variance is accounted for by the variance of the inefficiency effect.

[6] The production function results are not reported here but are available upon request from the authors.

Table 2—Maximum Likelihood Estimates of Inefficiency Effects

	Model 1	Model 2	Model 3	Model 4
Intercept	-1.3598***	-1.8341***	-2.8602***	-2.1549***
	(-5.7139)	(-8.5050)	(-5.9164)	(-8.5529)
Ln TOTALCOMP ($)	-0.4099***	-0.3569***	-0.3061***	-0.3147***
	(-30.3283)	(-24.2394)	(-13.6116)	(-9.3091)
SALARY (%)	—	—	2.0451***	1.4410***
	—	—	(13.0016)	(10.5156)
BONUS (%)	—	—	-0.3110	-0.4433
	—	—	(-0.9994)	(-1.1792)
RSTOCK (%)	—	—	0.7599	0.4099***
	—	—	(1.3502)	(3.6339)
OPTION (%)	—	—	2.6883***	2.1643***
	—	—	(18.4948)	(20.1372)
MGTOWN (%)	—	.7670*	0.7701***	-0.0607
	—	(1.9082)	(4.7355)	(-0.3335)
CEOYEARS	—	—	—	0.0206***
	—	—	—	(9.8064)
MID	1.6776***	2.2908***	1.6452***	1.8904***
	(15.1336)	(17.6010)	(10.0381)	(18.3017)
SMALL	3.2301***	3.4739***	2.6182***	2.5872***
	(20.7587)	(26.7849)	(11.2501)	(13.8571)
EX	3.5255***	3.6910***	2.7533***	2.7112***
	(22.9592)	(26.5504)	(10.9816)	(14.3049)
σ^2	0.9092***	0.8561***	0.7728***	0.6624***
	(36.4344)	(28.6155)	(10.7133)	(11.3535)
γ	0.7635***	0.7434***	0.7282***	0.6759***
	(95.7624)	(63.7639)	(26.6582)	(20.7823)
Log likelihood function	-3612.6989	-3609.1038	-3559.2407	-3556.1173
Likelihood Ratio test	305.7039	312.8941	412.6202	418.87
Avg Technical Efficiency	0.7918	0.7907	0.7871	0.7874
Number of Firms	1030	1030	1030	1030
Observations	4620	4620	4620	4620

t-values are in parentheses
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Furthermore, likelihood ratio tests on whether the inefficiency model parameters together with σ^2 and γ are equal to zero suggest that the inefficiency effects model is appropriate (i.e., the null hypothesis is strongly rejected; see the test statistic values reported at the bottom of Table 2). The average efficiency score (reported at the bottom of Table 2 for each model) is 0.79 suggesting that these firms could increase output by 26.6 percent if they were technically efficient.

Table 2 also reports the estimated coefficients for the compensation-related firm effects. Before proceeding with the main results, we should point out that we checked for the possibility of multicolinearity by estimating correlation coefficients, variance inflation factors (VIFs), and the tolerance, which is the proportion of the variance of each variable that cannot be explained by the other variables (the reciprocal of the VIFs). None of the VIFs are over ten, which indicates that multicolinearity should not be a concern (the values range from 1.2 to 5.6). The tolerance estimates are all high and the correlation coefficients are all below 0.7 to 0.8.

Note in Table 2 that—after controlling for industry and firm size—the level of CEO total compensation is negatively related to corporate production inefficiency. Thus, total CEO compensation—which comprises salary, bonuses, long-term incentive plans, restricted stock granted, stock options granted, and other types of compensation during a given year—is positively related to technical efficiency, which is our measure of long-term profitability and corporate health. What is perhaps more interesting is that the structure of CEO compensation also seems to be related to technical efficiency. CEO salary as a percentage of total compensation is negatively related to production efficiency. This could be a result of salary being relatively more important in the short term than in the long term.

The value of restricted stocks and stock options granted in a given year also are negatively related to production efficiency, and the coefficients are economically significant. It is possible that this result arises because technically inefficient firms grant more stocks and options to provide appropriate financial incentives to their top executive. The number of years as CEO of a company, however, is negatively related to the firm's technical efficiency. This finding could be partly attributed to a decrease in the CEO marginal productivity, career concerns, or both. Bonuses and management stock ownership directly relate the CEO compensation to accounting income and stock price and to production efficiency, but these relationships are statistically insignificant.

Concluding Remarks

This study analyzes whether the level and structure of top executive compensation are related to technical efficiency. By estimating a stochastic frontier model with inefficiency effects on panel data for S&P 1500 firms during the 1992-1998 period, we find that the level of top executive compensation increases technical efficiency. Restricted stocks and stock options granted to top executives, however, are negatively related to technical efficiency. Thus, when analyzing the impact of different compensation schemes on a firm's financial and economic performance, managers and policymakers should keep in mind that compensation based on stock market performance also may have an effect on whether firms use their resources appropriately and, thus, whether they improve technical efficiency.

If technical efficiency is tied to the long-term economic performance of the firm, then care must be exercised at the time of developing compensation schemes that reward top executives via primarily stocks and stock options because they could lead to a successful short-term financial performance at the expense of long-term economic growth. As such, it would be relevant to see whether there exist firm-specific optimal compensation packages that are able to reconcile these two goals of short-term financial performance with long-term economic growth.

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