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A DEA study of gender equity in executive compensation

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This study assesses whether annual and long-term compensation for senior executive women is equal to annual and long-term compensation for senior executive men. The group of executive women includes those women reported in the compensation tables of proxy statements for the companies in the Standard and Poors (S&P) 500 for 1997. Their compensation was compared to the compensation for two samples of executive men from S&P 500 firms using data envelopment analysis. The results indicate that the compensation paid to executive women is equitable to the compensation paid to executive men.

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Introduction

Over the past several years, the popular press and research studies have discussed gender differences in pay. Blau and Kahn[1] presented Bureau of Labor Statistics figures showing that the female-to-male ratio of median weekly earnings of full-time workers, which was 64.2 percent in both 1967 and 1979, rose to 74 percent by 1991. Catalyst[2] reported that the gender pay gap among top corporate executives was significant with women executives earning only 68 percent of the compensation paid their male counterparts. However, Renner *et al*[3] and Bertrand and Hallo[4] concluded that company performance and size characteristics explain most of the variation between men and women in executive pay.

The current study attempts to replicate the Renner *et al*[3] and Bertand and Hallo[4] findings using a different methodology, namely, data envelopment analysis (DEA). When dealing with public or social policy issues such as whether executive women are paid less than executive men, it is important that the same results can be replicated using a different methodology in order to gain more confidence in them. Different methodologies have different characteristics and different assumptions, which may lead to different results. For example, in researching the breakup of the Bell System, Charnes *et al*,[5] using a goal programming and constrained regression research approach, reached a different conclusion than did Evans and Heckman,[6] who used a regression approach. If different methodologies result in the same conclusions, then policy makers can be more confident in basing public policy on these results. If different methodologies result in different conclusions, then additional research should be undertaken before establishing public policy.

As noted above, in addition to gender, other factors such as corporate performance and size influence compensation. The economic theories of compensation (ie, agency theory) and moral hazard[7] suggest that firm performance should affect an executive's compensation. That is, to resolve the conflict between the interests of the company owners and executives, an executive's compensation should be tied to the performance of the company. Performance measures which have been shown to be influential in setting CEO compensation include return on assets,[8–10] shareholders' return,[9–14] return on equity,[8,12,13,15,16] and return on sales.[8,17]

Also, researchers have shown that corporate size influences CEO pay. Consequently, we include company size information in our study since it may also influence the complexity and job responsibility of other high-level executives. Corporate-size variables used in prior studies include sales level,[11,12,15,18] dollar value of total assets,[13,16] and market value.[19]

Description of the data

Selection of groups

The executives included in this study are the same as those included in Renner *et al*.[3] The subjects are among the five top-paid executives of the Standard and Poors (S&P) 500 companies. Their 1997 compensation is reported in their companies' proxy statements, accessed through the Securities and Exchange Commission (SEC) Edgar database. The SEC requires that companies report the compensation of the five top-paid executives, and these data are tabulated in a

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Table 1 Model variables

Output (compensation) variables
Executive annual compensation (EAC) (annual compensation to include base pay, bonuses, and other, in thousands of dollars)
Executive long-term cash equivalent compensation (EL-TCE)
Proportion of company ownership available to the executive (EXEC%CO) (securities underlying options/stock appreciation rights available to the executive divided by average number of company's common shares outstanding)
Input variables (compensation drivers)
Company size
Total assets (TA) (Average book value of total assets in millions of dollars) Sales (S) (in millions of dollars)
Company performance
Net income (in millions of dollars)
Company pay-scale philosophy
Chief executive officer annual compensation in thousands of dollars (CEOAC)
CEO long-term cash equivalent compensation (CEOL-TCE)
Proportion of company ownership available to the CEO (CEO%CO) (securities underlying options/stock appreciation rights available to the CEO divided by average number of company's common shares outstanding)

compensation table. We identified executive women by reviewing the individual names and pronouns in the compensation table and narrative portions of the proxy statements. If an executive's gender could not be established from the proxy, then the gender was determined through a telephone call to the company. We identified a total of 54 executive women. Two of these women are excluded because they are CEOs. CEOs were excluded from the study because, as discussed later, CEO compensation is used as a surrogate for company pay philosophy. Three other women were identified as the second highest-paid executives in the company. Since there were so few women at this pay level, they were excluded from the study since including them could bias the statistical results. Finally, three women were dropped from the data set because of incomplete data. This left 46 women representing the third, fourth, and fifth highest-paid executives in a company.

The group of executive women is compared to two different groups of executive men. One comparison group consists of all men who were the third, fourth, or fifth highest-paid executives in the same companies that employed the women. These men and women constitute Group A. There are 78 men in this group. Analyzing Group A will provide information on whether executive women are equitably paid when compared to executive men who are from companies in which women have broken through the glass ceiling.

The second comparison group of men includes the third, fourth, and fifth highest-paid executive men from companies that do not include top-paid executive women. We selected companies in the S&P 500, matched to Group A companies by industry (SIC code) and sales (a proxy for size). We included all the executives at the third, fourth, and fifth levels of pay. Given our assumption that a glass ceiling may exist in these companies, we examined historical data to verify that these companies did not report women among the highest paid executives in 1992 or 1995. There are 112 men in this group who are combined with the 46 women to constitute Group B. Comparing men and women in Group B will identify whether executive women are paid less than executive men from companies in which women have not broken through the glass ceiling.

Model variables

In the DEA framework, output variables are those variables that we would expect to be greater given the level of input variables. In our study, the output variables are executive annual compensation, executive long-term cash equivalent compensation, and executive options on shares of company stock. Table 1 summarizes the variables.

Executive annual compensation (EAC) is the total of the executive's base salary, bonus payments, and other annual compensation as reported in the proxy statement for 1997. *Executive long-term cash equivalent compensation (EL-TCE)* is the cash equivalent dollar value of restricted stock awards, long-term incentive plan payouts, and other long-term compensation as reported in the proxy statement for 1997. Securities underlying options/stock appreciation rights (OPTIONS) as reported in the proxy statements represents the number of shares that executives could purchase if they were to exercise their option rights as granted. For this study, OPTIONS is normalized by dividing it by the average number of the company's common shares outstanding. The resulting variable is given the acronym *EXEC%CO* and is included in the DEA model. It represents the proportion of company ownership available to the executive if he/she exercises his/her options.

Following the compensation theories discussed previously, we would expect the above compensation factors (output variables) to be greater for companies that were larger and better performing. As mentioned earlier, studies have shown that corporate size (eg, dollar value of sales, book value of total assets) and corporate performance (eg, measures of income) are significant in explaining CEO compensation. Thus, we would expect these types of variables to drive executive compensation.

The variables discussed below and defined in Table 1 are included as input variables in the DEA model. These input variables are referred to as compensation drivers in later parts of the paper. The 1997 values for these variables were obtained from Research Insight.

Net income (*NI*) is the bottom-line income for an executive's company for 1997. It is a measure of financial performance that includes operating revenues and expenses as well as gains and losses from extraordinary items and discontinued operations. *Total assets* (*TA*) is a measure of the company's size, using the average (beginning and ending of year balances) book value of company assets. *Sales* (*S*), another measure of the executive's company size, is the dollar value of sales for 1997 for each executive's company.

We also expect that chief executive officer (CEO) compensation would influence the level of compensation for other executives, since CEO compensation factors set the baseline for compensating other executives. There are three components of CEO compensation, which parallel the three components of executive compensation previously discussed. First, *CEO annual compensation* (*CEOAC*) is the total of the CEO's base salary, bonus payments, and other annual compensation as reported in the proxy statement for 1997. Second, *CEO long-term cash equivalent compensation* (*CEOL-TCE*) includes the cash equivalent dollar value of restricted stock awards, long-term incentive plan payouts, and other long-term compensation paid to the CEO as reported in the proxy statement for 1997. Third, CEOs receive options and stock appreciation rights which represent the number of shares that CEOs could purchase were they to exercise their option rights as granted. For this study, the number of shares of the underlying security that a CEO could purchase is normalized by dividing it by the average number of the company's common shares outstanding. The resulting variable is given the acronym *CEO%CO*. It represents the proportion of company ownership available to the chief executive officer if he/she exercises his/her options.

NI has the potential to be a negative value, yet DEA carries the assumption that all variables take on positive values. Consequently, we transformed all negative values of NI to positive values by adding the absolute value equal to the largest negative value for a variable plus 1 to each observation. Ali and Seiford[20] and Cooper *et al*[21] showed that this type of transformation did not affect the performance measures for the BCC (Banker, Charnes, Cooper[22]) version of the DEA model used in this study.

Data envelopment analysis

The DEA concept

DEA is a frontier-estimating, fractional-programming model. It identifies entities that are best performing (frontier entities) for the variables included in the model and evaluates all other entities relative to that frontier.[23] In contrast, the regression model used in Catalyst,[2] Renner *et al*,[3] and Bertrand and Hallo[4] is an averaging approach. The mathematical formulation for the ratio form of the BCC model is shown below (from Banker *et al*[24]).

$$\begin{aligned} &\text{maximize} && h_0 = \frac{\sum_r \mu_r y_{r0} - \mu_0}{\sum_i v_i x_{i0}} \\ &\text{subject to} && 1 \geqslant \frac{\sum_r \mu_r y_{rj} - \mu_0}{\sum_i v_i x_{ij}} \\ & && \varepsilon \leqslant \frac{\mu_r}{\sum_i v_i x_{i0}} \\ & && \varepsilon \leqslant \frac{v_i}{\sum_i v_i x_{i0}} \end{aligned} \qquad (1)$$

$$j = 1, \ldots, n;\ r = 1, \ldots, s, \text{ and } i = 1, \ldots, m$$

The variables are defined as follows:

h_0 is the scalar rating computed by the model for the executive under evaluation,
μ_r is a weight determined by the model for each compensation (output) variable r,
y_{r0} is the known or observed value for each compensation (output) variable r for the executive under evaluation,
μ_0 is computed by the model and indicates variable returns to scale,
v_i is the weight determined by the model for each possible compensation driver (input) variable i,
x_{i0} is the observed value for each compensation driver (input) variable i for the executive under evaluation,
y_{rj} is the observed value for each compensation (output) variable r for executive j,
x_{ij} is the observed value for compensation driver (input) variable i for executive j, and
ε is a non-Archimedean infinitesimal constant that allows the model to be solved.

DEA differs from the regression approach used in previous studies in several additional ways. First, unlike regression, DEA requires no assumption about the functional form nor does it require the imposition of a specific functional form to relate the input and output variables.[23] That is, it neither assumes nor requires that all entities (observations) in the analysis follow the same production function. Consequently, DEA is more flexible in recognizing and accommodating observations that might have different production functions (ie, means of relating the compensation drivers and compensation variables) than is regression analysis. However, it should be noted that DEA does assume a piecewise linear relationship between input and output variables in calculating an entity's (executive's in this study) rating.

Second, DEA focuses on optimizing individual observations in contrast to regression, which focuses on averages and parameter estimates for classes of entities.[23] If there are 100 entities under analysis, then there will be 100

optimizations and model solutions (one for each entity) using DEA as compared to one solution under regression. Thus, the DEA results are entity (observation) specific and do not imply an average entity or class of entities.

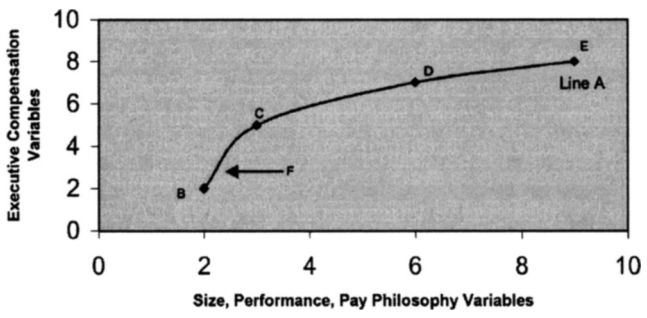
Finally, DEA handles multiple output and multiple input variables simultaneously.[23] Consequently, DEA readily recognizes the substitutability of different inputs and outputs. For this study, that means the substitutability of different types of executive compensation in companies' executive compensation schemes is accommodated. It does this without resorting to specifying an *a priori* weighting scheme or requiring that the variables be defined using a common unit of measure.[23]

The above attributes of DEA are very important for this study since companies use a variety of methods to compensate their executives. For example, Anderson *et al*[25] show that stock options are a more important part of the compensation package in the information technology industry than they are in other industries. DEA's flexibility allows it to readily accommodate these different compensation schemes.

The DEA research approach

Figure 1 is a graphical representation of DEA as used in this research. The axes represent vectors of weighted compensation variables and compensation drivers, where each executive has an individually weighted vector. The *Y*-axis represents a vector of weighted executive compensation variables (EAC, EL-TCE, and EXEC%CO). The objective is to maximize these variables given the level of compensation drivers. The *X*-axis represents a vector of weighted compensation drivers that influence the size of executive compensation. This vector includes a company financial performance measure (NI), company size variables (S and TA), and CEO compensation variables (CEOAC, CEOL-TCE, and CEO%CO).

The executives with the best ratio of compensation variables to company size, performance, and CEO compensation variables (compensation drivers) create the frontier, shown as Line A in Figure 1. They are the best-paid executives given the level of company financial performance, size of the company, and CEO compensation. Those executives who are not on the frontier are paid less relative to the company's financial performance, size, and CEO compensation than are the executives who are on the frontier. In Figure 1, Line A is formed from Points B, C, D, and E. These points represent the executives who are the highest-paid executives given their company's level of NI, S, TA, CEOAC, CEOL-TCE, and CEO%CO and relative to the other executives included in the data set. Point F represents a lower paid executive. The executives on the frontier receive a DEA rating of one. The executives off the frontier are given a DEA rating of less than one as determined by their Euclidean distance from the frontier.



This model can be placed in the context of gender equity in executive compensation as follows. Our research methodology focuses on determining the distance that executives are from the frontier, and whether the average distance for executive women differs from the average distance for executive men. If executive women are paid less than executive men, then the women will be, on average, further from the frontier and will receive lower DEA ratings.

DEA analysis and results

There are six analyses discussed below. They are coded by a letter and number combination. The letter, A or B, indicates the group of executives included in the analysis. These groups were defined earlier in the paper.

The number indicates the type of executive compensation included in the analysis. A 1 indicates that only annual compensation is used in the analysis. A 2 indicates that only long-term compensation is included as output variables in the analysis, and A 3 indicates that both annual and long-term compensation variables are included in the analysis. Hence, analysis A1 includes executive women and men from the same companies and uses only annual compensation variables in the analysis.

The general hypothesis for each analysis is that there is no difference in compensation between executive women and executive men. Thus, the null hypothesis to be tested in each analysis is that there is no difference in DEA ratings between executive women and executive men. Since the distribution of the DEA ratings is unknown, the Mann–Whitney *U*-test is used in all analyses to determine if there is a statistical difference between executive men and executive women compensation.

Table 2 provides the means and medians for the independent variables for the data sets used in this research. S&P 500 values are for all companies in the S&P 500 and are provided solely for comparison purposes.

Executive annual compensation as sole output variable

These analyses have one compensation variable (EAC) and

Table 2 1997 company descriptive data

Data sets	Total assets (in $ millions) Mean (median)	Sales (in $ millions) Mean (median)	Net income (in $ millions) Mean (median)	CEO annual pay (in $ thous.) Mean (median)	CEO long-term cash (in $ thous.) Mean (median)	CEO stock rights (in percentage) Mean (median)
S&P 500	21 617	9614	643	Not available	Not available	Not available
	(6230)	(5030)	(315)	Not available	Not available	Not available
A1 companies	26 756	8140	583	2397	Not used	Not used
	(6446)	(4482)	(313)	(1579)	Not used	Not used
A2, A3 companies	34 653	9455	795	2505	1239	0.17%
	(9186)	(5079)	(413)	(1535)	(255)	(0.07%)
B1 companies	31 291	9632	632	2319	Not used	Not used
	(7376)	(6744)	(329)	(1856)	Not used	Not used
B2, B3 companies	38 347	11 243	866	2365	1570	0.22%
	(7750)	(6778)	(394)	(1885)	(284)	(0.13)

Table 3 Mann–Whitney *U*-test results summary

Analysis	*z*-statistic	*P*-value	Compensation equivalency results
A1	−0.766	0.44	Women = men
B1	−1.046	0.29	Women = men
A2	1.413	0.16	Women = men
B2	−1.638	0.102	Women = men
A3	0.972	0.33	Women = men
B3	−0.927	0.35	Women = men

A1 analysis. Our specific hypothesis for this analysis is that the annual compensation for executive men and executive women is not different in companies where women have broken through the glass ceiling. As shown in Table 3, the Mann–Whitney *z*-statistic is −0.766 with a *P*-value of 0.44. We cannot reject the hypothesis that executive women receive annual compensation equal to executive men. There appears to be gender equity in senior executive annual compensation in firms with both men and women in the executive ranks, that is, where women have broken through the glass ceiling.

B1 analysis. Our specific hypothesis for this analysis is that executive women receive annual compensation comparable to annual compensation for executive men from companies that do not have women in their five top-paid positions. The Mann–Whitney *z*-statistic is −1.046 with a *P*-value of 0.29. Thus, there is no difference in annual compensation between executive women and executive men from companies that do not have executive women among their five top-paid executives. Even though the glass ceiling has not been broken in these companies, it does not appear that their top-paid executives are paid more that executive women in other S&P 500 companies.

Long-term executive compensation variables as output variables

The next DEA procedure includes only long-term compensation variables in the analysis. Hence, it uses two executive compensation variables (EL-TCE and EXEC%CO) and five compensation drivers (CEOL-TCE, CEO%CO, NI, S, and TA). For this set of analyses, the number of executives included in each analysis (Groups A and B) was reduced because DEA does not handle zero values. Consequently, we excluded executives with a long-term compensation factor of zero value in his or her data set. This left 33 women, 53 men in Group A, and 67 men in Group B in the data set.

A2 analysis. As shown in Table 3, the Mann–Whitney *z*-statistic for this analysis is 1.413 with a *P*-value of 0.16. Consequently, the hypothesis of no difference in long-term compensation between executive men and executive women cannot be rejected. Executive women receive the same long-term compensation as do their male counterparts in companies where the glass ceiling has been broken.

B2 analysis. The Mann–Whitney *z*-statistic is −1.638 with a *P*-value of 0.102. Thus, the hypothesis that executive women and executive men from companies that do not have women as part of their top five-paid employees receive comparable long-term compensation is not rejected at the 0.10 level of significance.

The negative sign for the *z*-statistic indicates that the DEA ratings for women were higher than for men. A higher DEA rating indicates that women were, on average, closer to the frontier and thus, paid relatively more than men.

Some analysts might consider the above results for the B2 Analysis to be borderline significant. To gain insight into why the above results might occur, we analyze the ratio of shares underlying options and stock appreciation rights granted to executives to shares underlying options and stock appreciation rights granted to CEOs. In other words, we look at an executive's right to shares of stock as a percentage of the CEOs right to shares of stock.

H_0: The ratio of executive shares to CEO shares for women is greater than this ratio for men in Group B.

The *t*-test for differences in means between groups indicates a difference that is significant at the 0.10 level. Consequently, an explanation for why the B2 Analysis provides some indication that executive women are paid more than executive men is that women were awarded more

rights to the company's stock (as a percent of the CEO's rights to the company's stock) than were executive men.

It is possible that companies that have executive women grant a greater number of options for shares and stock appreciation rights to all top executives (women and men) than do companies that do not have executive women. If this is the case, the above results would reflect a difference in corporate compensation philosophy and not a gender difference. To examine this possibility, we test the following hypothesis:

H_0: The ratio of executive shares to CEO shares for women and men in Group A is greater than this ratio for men in Group B.

The *t*-test for the differences in means between the groups is not significant at the 0.10 level. Consequently, there appears to be a gender difference in the granting or stock options and appreciation rights rather than a difference in corporate compensation philosophy.

All executive compensation variables as output variables

The final DEA procedure includes annual and long-term compensation variables in the analysis. Hence, it uses all three executive compensation variables (EAC, EL-TCE, and EXEC%CO) and all six cost drivers. For this set of analyses, the number of executives included in each analysis (Groups A and B) is the same as for analyses A2 and B2.

A3 analysis. For this analysis, we hypothesize that there is no difference in annual and long-term compensation between executive women and executive men from the same companies (ie, companies that have senior executive women). The test statistic for this analysis is 0.972 with a *P*-value of 0.33. Thus, our hypothesis that there is no difference in pay between executive women and executive men cannot be rejected.

B3 analysis. The Mann–Whitney *z*-statistic for this analysis is −0.927 with a *P*-value of 0.35. Our hypothesis is not rejected. Women receive total compensation comparable to executive men from companies at which women have not broken the glass ceiling.

Comparison to other studies

The above findings are consistent with the regression results in Renner *et al*[3] and Bertrand and Hallo[4] for annual compensation. Consequently, there is additional evidence that women executives receive annual compensation equivalent to men executives when company performance, size, and pay philosophy (as indicated by CEO compensation) are considered. Also, our results indicate that women seem to receive a larger share of their compensation in the form of stock options, which is similar to the findings of Bertrand and Hallo.[4] Bertand and Hallo hypothesize that one might expect women executives to be paid more than men executives because the women had to have more ability than the men to get to the same level.

However, our results contradict the Catalyst[2] conclusion that women executives are underpaid when compared to men executives. This contradictory finding appears to be primarily the result of Catalyst not adequately treating differences in company size and performance. Also, Renner *et al*[3] found indications that executive women received less total compensation than executive men. However, this pay gap was eliminated when they controlled for level of executive responsibility.

Conclusions

In this study, we use DEA to evaluate whether there is gender equity in senior executive compensation. After controlling for company size, company performance, and company pay philosophy (as set by the level of CEO compensation), our results, using DEA, showed no difference in pay between men and women. Consequently, we conclude that, on average, once a woman reaches the senior executive ranks, her pay is equitable to a man's pay. Once women make it to the top, factors other than their gender explain differences between their salaries and those of comparable men. These findings are consistent with those of Renner *et al*[3] and Bertrand and Hallo.[4] However, the findings differ from Catalyst[2] and Blau and Kahn[1] who concluded that women are paid less than men.

Our research results should not be misinterpreted to say that that there is no glass ceiling. In fact, in 1997 there were only 54 women, a mere 2 percent of the 2500 top-paid executives in S&P 500 companies. Further research should attempt to discover the reasons for women's low representation among the highest compensated executives.

Finally, the results of this research are dependent on failing to reject a null hypothesis. Some researchers would consider this an unsatisfactory outcome and a limitation of the research results. We recommend further investigation of the executive gender pay gap issue.

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