Gender and Dynamic Agency: Theory and Evidence on the Compensation of Female Top Executives*

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November 2006

1 Introduction

There are substantial gender differences among top executives. Women are still under represented at the upper ranks of the corporate structure and tend to work in smaller corporations. The gender gap in total compensation is 30% – a gap comparable to the one observed for the overall population. This paper provides evidence of considerable gender differences in the structure of compensation of top executives and attempts to rationalize them based on a dynamic agency model of executive compensation.

We first document three facts regarding how the structure of compensation for top executives varies by gender using the ExecuComp dataset. We show that female top executives receive a larger fraction of total compensation in the form of salary. They also receive a lower fraction of their pay in the form of delayed compensation. Gender differences in pay-performance sensitivities are also substantial. Female executives receive on average an additional 4 cents in current compensation for each additional 1000 dollars increase in shareholders' wealth, while males receive 7 cents. Our results control for the fact that women tend to manage smaller companies and are less likely to be CEO, Chair, or company Presidents. These facts guide our theoretical analysis of dynamic contracts and gender for this group of professionals. In particular, we use them to inform our interpretation of gender within the context of a dynamic moral hazard model of executive compensation.

Survey and experimental evidence points to the existence of a pervasive set of culturally-related barriers. These include lack of mentoring and role models, exclusion from informal

*First Draft. This paper is based upon work supported by the National Science Foundation under Grant No. 0551511. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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networks, gender based stereotyping, display of style different than the organizational norms, difficulties in engaging in negotiations and inhospitable corporate culture.[1] Based on this evidence, we consider two alternative hypotheses regarding possible determinants of gender differences in the structure of compensation. The first hypothesis is that female executives have lower impact. Specifically, we allow for a lower effect of effort on the probability of high profits for female executives (probability-impact). Alternatively, we consider the case where for given effort, female executives give rise to higher volatility in a firm's profits (productivity-impact). The second hypothesis is that female executives have lower effectiveness - that is, they have a smaller role in the determination of a firm's profits, for a given impact of their effort. We find that the version of the model in which female executives have lower effectiveness is consistent with the observed gender differences in the structure of executive compensation. The version with lower impact fails to replicate, among the other things, the lower fraction of performance pay earned by female executives.

2 Evidence on the Compensation of Top Executives

We use Compustat data on executive compensation (ExecuComp) to investigate how the structure of compensation of top executives varies by gender. We document the following basic facts. First, women in top executive positions tend to receive a lower share of their compensation in the form of incentive pay. Second, they also receive a lower proportion of total earnings in the form of delayed compensation. Third, the compensation of male executives displays a higher pay performance sensitivity than that of female executives. Our findings control for firm's size (using market value or total employment), for firm or industry fixed effects and for occupational categories within the executive ranks - that is, they take into account the fact that female executives tend to work in smaller firms, are less likely to be CEO, Chair, or company Presidents and tend to be over-represented in industries where incentive pay and delayed compensation are relatively less important components of total pay.

2.1 The data set and variable definitions

The Standard & Poor's ExecuComp data set includes information on the compensation of top executives in firms belonging to the S&P 500, the S&P Midcap 400 and the S&P SmallCap 600 for the period 1992 to 2004. The sample includes 139,680 executive-year observations. The number of top executives sampled in each firm ranges from 1 to 15 top-executives. This variability depends on firms size. The vast majority of firms (around 70%) report information for 4 to 9 top executives, around 45% of the firms in the sample report information for 5 to 6 executives.

[1] See the 2004 Catalyst's report on "Women and men in US Corporate Leadership" and Babcock and Laschever (2003).

Although women are a relatively small part of the sample, we observe a substantial increase in their numbers over this time period. The share of female top-executives increased from 1.6% of the sample in 1992 to 6.8% in 2004. It is interesting to look at the break down of the fraction of female executives in the sample by their ranking in the firm. We have the information on whether the executive is the CEO of the firm. Not surprisingly, the fraction of female CEOs in the sample is very small. It ranges from 0.23% in 1992 to 1.8% in 2004. There are more women in relatively lower executive positions. If we exclude CEOs the fraction of women in the sample ranges from 1.5% in 1992 to 7.9% in 2004.

All the measures of total compensation considered are based on Compustat definitions. The first definition of total compensation, TCC, is the most 'conservative.' It is a measure of total current compensation that only includes salary and bonuses. The second definition, TDC1, adds to these two items additional annual compensation, total value of restricted stock granted, total value of stock options granted (using the Black-Scholes formula) and long term incentive payouts. The third definition of total compensation, TDC2, substitutes the total value of stock options granted in the previous definition with the net value of stock options exercised.

We also define a variable that contains information on the total value of delayed compensation (DC). This variable includes the value of long term incentive payout, the value of restricted stock granted and the total value of stock options granted (the latter computed by using the Black-Scholes formula.) The variable that describes the long term incentive payouts (LTIP) represents the amount paid out to the executive under the company's long-term incentive plan. These plans measures the company's performance over a period of more than one year. Table A3 in the Data Appendix summarizes the average long-term payout duration for the executives in our sample as summarized by the Compustat variable PERIOD. This variable indicates how many years in the future the executive will receive a payout under the plan (number of years is rounded). As shown in the table, the average time horizon of the executives' long-term incentive payout typically varies between three and four years. We use the variable BLK_VALUE as a measure of the total value of stock options granted. This variable represents the aggregate value of all the stock options granted to the executive during the year as valued using the S&P's Black Scholes methodology. The calculation of this figure takes into account the volatility of the executive's company. Table A3 also reports information on the time horizon of stock options granted. We use the Compustat variable EXDATE, the expiration date of the stock option, to construct a variable that represents the distance between the current (fiscal) year and the year in which the stock option will expire. The time-to-expiration date for most stock options granted varies between nine and ten years. Hence we classify both stock options granted and long term incentive payouts as delayed compensation.

We use the variable MKTVAL to measure firm's market value. This variable summarizes the close price for the fiscal year multiplied by the company's common shares outstanding. We use the Compustat variable SALES for firm size. This variable measures the net annual sales as reported by the company. We also use the number of total employees as reported by the company (EMPL) as an alternative measure of firm size.

All the variables related to executive compensation are expressed in thousands of dollars. The market value and the volume of sales of the company are expressed in millions of dollars. The number of employees is measured in thousands. All the nominal variables are deflated using the CPI with base 2000 from the BLS.

Information on the age and tenure of top executives are computed based on age in the most recent fiscal year (P_AGE_2) and on the year in which the executive joined the firm (JOINED_C), respectively. It should be noted that age is missing for almost 90% of observations and tenure is missing for 70%. Missing observations on age and tenure are equally distributed across genders. Moreover, the composition of the sub-samples of executives that report information an age, tenure, or both, is strictly comparable to that of the overall sample in terms of gender, job titles and average total compensation (for all definitions). Finally, we constructed 11 occupational categories based on the "title" variables in ExecuComp (TITLE, which shows the most recent title, and TITLEANN, which shows the title in a given fiscal year). We discuss the details about the construction of these job categories in the Data Appendix. In our analysis we include dummy variables corresponding to these 11 job "titles" in the regressions.

Summary statistics for the main variables used in the analysis are reported in Table A1 and A2 in the Data Appendix. The share of total compensation paid to top executives in form of salary ranges from around 70 per cent for the definition of total compensation that includes only salary and the monetary bonus to 40-50 per cent for the second and third definitions which include more measures of incentive pay. Female executives earn less than males independently on the definition of total compensation.and the difference is statistically significant. Female executive are on average three-year younger than male executives (49.5 and 52.2 years, respectively). Not surprisingly they also have a 3.4-year gap in their average tenure at a firm (7.4 and 11 years, respectively). Also, female executives tend to work in smaller firms, as characterized by the total value of real sales, but this gender difference is smaller if we measure firm size using the total number of employees. Descriptive statistics on the incidence of job titles by gender (reported in Table A2) show that women are less likely to hold the title of Chair/CEO, President or Vice-Chair but are more likely to hold the titles of COO, Vice-President, senior Vice-President or executive Vice-President. As shown in the last two columns of Table A2, differences in the incidence of job titles between genders are statistically significant at the 1 percent level. Note that even in the job categories where female executives are more likely to be found, such as most of the Vice-President positions, the average total compensation (salary share of total compensation) is significantly lower (higher) for women than for men.

2.2 Gender differences in incentive pay

We run regressions of the salary share of total compensation on a gender dummy and year dummies. As documented in Bertrand and Hallock (2001), using the same data set for the period 1992 to 1997, a large fraction of the observed gender differences in pay among top executives is due to the fact that women tend to work in smaller corporations where a smaller component of compensation packages is linked to performance. In addition, they show that industry fixed effect also contribute to explain the gender gap since women tend to be 'segregated' in industries such as health care where incentive pay is less important. Hence, we consider two specifications. In the first one we control for firm's size (using the value of real sales) and for industry fixed effects (using 115 dummies). In the second, we include firms fixed effects.[2] Both specifications deliver similar results. However, the regressions that include firm fixed effects have more explanatory power. Hence, in most of our analysis, we will focus on the results obtained when we control for firm fixed effects. We consider different specifications that progressively add characteristics that substantially differ by gender, such as, job titles, tenure and age, to the set of control variables. All specifications include time dummies.

Table 1 summarizes our results when we use the most conservative measure (TCC = bonus + salary) to construct the salary share of total compensation (that is, the dependent variable in the regression). In order to capture gender differences in this share we simply regress our dependent variable on a female dummy. Robust standard errors that correct for clustering at the firm-year level are in parentheses. The first two columns show how the share of "base" pay varies across genders when we control, respectively, for firm size and industry (column 1) and firm fixed effects (column 2). The estimates of the female dummy coefficient indicate that female top executives' salary share of total compensation is 1.8 to 1.4 percentage points higher than males. These estimates imply that while the salary share of total compensation is 74% (73%) for the average male top executive (the constant term in the regression), it increases to 76% (74.4%) for the average female top executives. This difference is non-negligible since the average top executive in our sample earns approximately 7 hundred thousand dollars a year in salary and bonuses. In columns 3 to 5 we progressively control for factors that might be driving this observation. For example, since lower ranked executives receive a lower fraction of their total compensation in the form of incentive pay, the gender difference in the salary share of total compensation could simply be due to the fact that female top executives tend to be over-represented at lower ranks of the corporate structure. Indeed we find that the estimated female dummy coefficient drops in size and significance once we control for job titles (see column 3). However, the difference is still statistically significant and sizeable. In column 4 and 5 we also add controls for tenure and age, respectively. As discussed above this considerably reduces the size of our sample but it does not affect its gender composition (as it would be the case if,

[2] In this case we cannot also control for industry, since industry does not vary within firms (for the most part).

for example, information on age were only available for the top three executive positions). We still find a significant gender difference in the salary share of total compensation. Interestingly, once we control for the age of top executives, the gender difference is as large and as significant as the one observed when we do not control for job titles (1.6 percentage points).

Table 1: Gender Differences in Salary Share of Total Compensation

	Dependent Variable: Salary/TCC				
female	.018***	.014***	.005**	.007*	.016***
	(.002)	(.002)	(.001)	(.003)	(.006)
constant	.74***	.73***	.71***	.69***	.68***
	(.004)	(.003)	(.003)	(.005)	(.014)
Adj R-squared	0.18	.43	.44	.44	.52
Number of observation	138,909	139,310	135,476	40,790	16,664
year dummies	✓	✓	✓	✓	✓
firm size & industry	✓				
firm effects		✓	✓	✓	✓
job titles			✓	✓	✓
tenure				✓	
age					✓

Notes: Based on ExecuComp, Compustat Data. Robust standard errors, clustered at firm-year level, in parentheses. *Signif. at 10% level, ** signif. at the 5% level, *** signif. at the 1% level.

Table 2 shows how the share of "base" pay varies across genders as we progressively add incentive pay components to the definition of total compensation in the denominator. Columns 1 to 3 present the results for the second definition of total compensation (TDC1), column 4 to 6 present the results for the third definition (TDC2). Finally, we report gender differences in the share of delayed compensation (DC/TDC1) in the last three columns of the table. For each of the three dependent variables we discuss the results obtained for three specifications. The first only controls for firm fixed effects, the second adds job titles and the third also include age among the regressors. We find that women in top corporate jobs tend to receive a larger share of their compensation in the form of salary. Not surprisingly this difference is larger than the one observed using the first definition of total compensation, which includes the smallest amount of performance-based components. As we increase the amount of incentive pay included in the denominator, gender differences in the fraction of base pay also tend to raise. According to the second definition of total compensation women's salary share is 2.5 percentage points larger than men's. The largest gender difference, 3.9 percentage points, is observed when we include the net value of stock options exercised in the measure of total compensation at the denominator. These are significant differences since the average total compensation for top executives ranged, depending on the definition, between 1.6 to 2 million dollars over this time period. Note that, as we move across columns, we are progressively expanding the definition of total compensation to include more delayed-incentive-pay components. Hence, female top executives are characterized by a lower pay-for-performance share both in terms of current incentive-pay and in terms of delayed incentive-pay. To reiterate this point we report the gender difference in the share of delayed compensation (stock options and long-term incentive payout plans) in the last two columns of the table. The share of delayed compensation for female top executives is 1.6 percentage points lower than that of male executives for the first specification. Our findings are robust to the inclusion of job titles and age controls in the regressions (except for column 8).

Table 2: Gender Differences in Salary Share and "Delayed" Share of Total Compensation

	Dependent Variable								
	Salary/TDC1			Salary/TDC2			DC/TDC1		
female	.025***	.009***	.027***	.039***	.023***	.038***	-.016***	.0042	-.026**
	(.003)	(.003)	(.009)	(.003)	(.003)	(.009)	(.003)	(.003)	(.011)
constant	.52***	.48***	.42***	.58***	.53***	.62***	.26***	.28***	.42***
	(.005)	(.005)	(.018)	(.004)	(.004)	(.018)	(.005)	(.005)	(.023)
Adj R-squared	.41	.43	.49	.35	.37	.44	.34	.35	.41
N. obs.	117,623	115,956	15,041	139,510	135,666	16,699	117,623	115,956	15,041
year dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓
firm effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
job titles		✓	✓		✓	✓		✓	✓
age			✓			✓			✓

Notes: Based on ExecuComp, Compustat Data. Robust standard errors, clustered at firm-year level in parentheses. *Signif. at 10% level, ** signif. at the 5% level, *** signif. at the 1% level.

2.3 Gender differences in Pay Performance Sensitivities

In this section we study whether there are also significant differences in pay performance sensitivities across genders. Our exercise consists of regressing the change in total compensation of an executive on the change in firm's market value, a female dummy and an interaction term between the female dummy and the change in the firm's market value. Since we are interested in measuring pay performance sensitivities we use the variable TCC which only includes salary and current bonuses as a measure of total compensation. We use the Compustat variable MKTVAL to compute the change in stockholders' wealth.

Table 3 reports the results of our analysis for different specifications of the regression that progressively control for characteristics that sistematically differ by gender. As in the previous tables, robust standard errors that correct for clustering at the firm-year level are in parentheses. Column 1 reports our results for the specification that includes time dummies and controls for firm size, measured using the real value of sales in the current year, and job titles. Column 2 reports the results when we add tenure at the current firm to the set of controls. Finally, column 3 reports the results when we control for the age of top executives in addition to firm's size and job titles.

The first two rows of the table report the estimated coefficients for the main variables of interest: the change in firm's market value and its interaction with the female dummy. We find that the elasticity of total compensation to changes in shareholders' wealth is roughly 70% higher for men (.0074) than for women ($.0074 - .0032 = 0.0042$). This is true controlling for differences across genders in firm's size and job titles (see column 1). These coefficients should be interpreted as follows. A female top executive would receive an additional 4.2 cents total compensation for each additional $1,000 increase in shareholders' wealth. Under similar circumstances, a male top executive would receive an additional 7.4 cents in pay. The gender difference in pay performance sensitivities is statistically significant at the 10% level. As we add controls for tenure (column 2) and age (column 3) the gender differential becomes larger and stronger (the difference is now statistically significant at the 1% level). Entries in column 2 (column 3) imply that a female executive would receive an additional 2.8 (1.4) cents total compensation for each additional $1,000 increase in shareholders' wealth in contrast with the 9.8 (8.1) cents that would be received by a male top executive. Once we control for the fact that female top executives are younger and have lower tenure, we find that pay performance sensitivities for male top executives are three to four times larger than female's.

The intercept and the estimated coefficient on the female dummy (row 3 and 4 in the table) imply that the "base" change in compensation, if the market value of the firm is unchanged, is slightly higher for women than for men - 68.3 and 61.3 respectively. That is, a female executive would receive an average pay increase of $68,300 in years in which shareholder do not see an increase in wealth whereas a male top executive would only receive $61,3000 in the same situation. However, the gender difference in the "base" change in compensation is not statistically significant. This finding is common across all specifications.[3]

[3] Note that the female dummies are jointly statistically different from zero at the 1 per cent level (Chow test). The test is run under the null hypothesis that the constant term and the two coefficients (for the change in firms' market value and for the level of real sales) jointly differ by gender.

Table 3: Estimates of Pay-Performance Sensitivity by Gender

	Dependent Variable: $\Delta(TCC)$		
Δ in shareholders	.0074***	.0098***	.0081***
wealth	(0.001)	(0.002)	(0.002)
Δ in shareholders	-.0032*	-.0070***	-.0067***
wealth*female	(0.002)	(0.002)	(0.002)
female	7	4.4	16.5
	(5.5)	(8.21)	(12.9)
intercept	61.3***	105***	90.2***
	(8.0)	(11)	(8.5)
year dummies	✓	✓	✓
firm size (sales)	✓	✓	✓
job title	✓	✓	✓
tenure		✓	
age			✓
Adj R-squared	.01	.02	.01
N. obs.	106704	32361	14188

Notes: Robust standard errors, clustered at firm-year level, in parentheses. *Signif. at 10% level** signif. at the 5% level, *** signif. at the 1% level.

Our estimated coefficients are of the same order of magnitude of those reported in Jensen and Murphy (1990) (JM henceforth) and Murphy (1986) for a sample of CEOs observed during the years 1974-1986. However, our numbers are slightly larger than the numbers they obtained. The difference with respect to the JM results is not surprising for two reasons. First, JM's sample stops in 1984 whereas our sample cover the period 1992-2003. Hence our analysis focuses on a decade when performance-based compensation of executives became increasingly more important. Second, we use a slightly different definition for the change in the wealth of shareholders. In our analysis the change in the market valuation of a firm is given by the inflation-adjusted change in the market value of the firm between the beginning and the end of each period. JM define the change in shareholders' wealth as the product of the beginning of the period market value of the firm multiplied by the inflation-adjusted rate of return on common stock. This is because in their model effort at one point in time affects the probability of a good outcome (the firm's performance) in the next period. This is not the case in our model. Hence the definition that we use for the change in the market value of a firm.[4]

[4] We have also performed our analysis following the JM definition of a firm's market value and found results that are in line with their estimates (although, obviously, the estimates are still higher given that our sample is more recent).

3 Optimal Executive Compensation and Gender

Surveys of top executives suggest that female executives experience greater difficulties relative to men in corporate leadership roles due to lack of mentoring, lack of professional role models, lack of professional networks and gender stereotyping (Catalyst, 2004). This evidence can be used to rationalize a view that female top executives might have lower ability to influence firm performance than males with similar characteristics, other things equal. Moreover, female top executives tend to be over-represented in small firms. This observation suggests that it may be important to model a competitive labor market for top executives in which demand originates from firms of different size, as in Himmelberg and Hubbard (2000), where larger firms will pay a premium to attract male executives.

We consider two alternative hypothesis on the source of female executives' lower ability to influence firm performance in a dynamic hidden effort model of executive compensation, as in Murphy (1986). First, we allow for female effort to have lower *impact* on firm outcomes. Specifically, we assume that the marginal expected increase in firm performance stemming from a marginal increase in effort is lower for female executives. Second, we allow for male executives higher *effectiveness*. This could equivalently originate from higher productivity or from a lower utility cost of effort.

In order to distinguish between these alternative hypothesis, we confront the model's predictions under these alternative assumptions with the three facts regarding gender differentials in the structure of executive compensation documented in section 2. We will concentrate on the following three predictions:

1. Female top executives receive a lower fraction of their compensation in the form of incentive pay than male top executives.
2. Female top executives share of delayed compensation is lower than for male executives.
3. Earnings of female top executives exhibit lower pay-performance sensitivities than male top executives, for a variety of measures of executive compensation.

In addition, female top executives have lower earnings than male top executives with similar characteristics. This would be predicted by the model both under the assumption of lower female impact, and under the assumption of lower effectiveness.

One might ask why shareholders would be willing to hire female executives given their assumed lower impact/effectiveness. Advocating antidiscrimination laws, one could argue that if two candidate executive officers have similar qualifications, shareholders would not be able to exclude the female candidate. However, if we assume a competitive labor market for top executives, the lower impact/effectiveness of female executive officers will translate in a lower value of their outside option, which would in turn lower the costs of hiring them for firms. Hence, shareholders might be indifferent between hiring female and male executives. Alternatively, female executives might be hired by firms that are financially constrained. This is consistent with the observation that female executives are over-represented in smaller firms which have been found to face more stringent financial constraints (Gertler and Gilchrist, 1994). We plan to formally model a competitive market for top executives in future drafts. To address this concern in the current version, we simply calibrate the difference in outside option across genders to ensure that shareholders are indifferent between hiring a female or male executive officer.

3.1 The Model

The model has two agents the principal (shareholder) and the agent (executive officer). They both live for $T = 2$ periods and discount the future at rate $\beta \in (0, 1)$. Both principal and agent derive utility from a perishable consumption good. The principal is risk neutral and the agent is risk averse. The agent's period utility function is $u(c, e)$, where $u_c > 0$, $u_e < 0$ and u is strictly concave. Here, c denotes consumption and e the agent's effort. Let E denote the compact set of available effort levels. The agent exerts effort in each period. By choice of effort, e_t, the agent determines the probability distribution of output, $y_t \in Y$, where Y is the set of possible output levels, and $t = 0, 1$. We assume Y is countable and finite. We denote with $f(y; e)$ the probability that output is equal to $y \in Y$ if effort is equal to e. We assume $f(y; e) \in (0, 1)$ for all $e \in E$ and $y \in Y$, and $\sum_Y f(y; e) = 1$.

We make the following informational assumptions. In each period, effort is *private information*, while output is *observable*. Hence, the shareholders face a dynamic moral hazard problem[5]. We denote with $w_t(y) \in [0, y]$ the compensation scheme offered to the executive by the shareholders for $t = 0, 1$. The compensation scheme solves a dynamic contracting problem, which we describe in its recursive form. At $t = 1$, for given outside option of the executive in that period, the shareholders choose an effort level to implement and a compensation scheme, contingent on realized output, to maximize expected profits, subject to a participation constraint and an incentive compatibility constraint for the executive. At $t = 0$, for given outside option of the executive for that period, the shareholders choose an effort level to implement, a compensation scheme and a continuation utility value, contingent on realized output, to maximize expected discounted profits subject to the executive's participation constraint and an incentive compatibility constraint. The continuation utility assigned by the shareholders at time 0 will determine the executive's outside option at the beginning of time 1. In both periods, the outside option influences the participation constraint for the executive. The dependence of compensation in both periods, and of continuation utility in period 0, on observed output is necessary to provide incentives, since the executive's effort is private information.

Formally, the problem is as follows. At $t = 1$, shareholders take v_1 as given and choose e_1

[5] Since by assumption $f(y; e) \in (0, 1)$, shareholders cannot infer effort for sure from any realization of y.

and $w_1(y)$ to solve:

$$V_1(v_1) = \max_{e_1 \in E,\ w_1(y) \in [0,y],\ y \in Y} \sum_Y (y - w_1(y)) f(y; e_1) \tag{Second Period}$$

subject to

$$\sum_Y u(w_1(y), e_1) f(y; e_1) \geq \sum_Y u(w_1(y), e') f(y; e') \text{ for all } e' \in E, \tag{1}$$

$$\sum_Y u(w_1(y), e_1) f(y; e_1) = v_1. \tag{2}$$

At time 0, shareholders choose e_0, $w_0(y)$ and continuation utility $v_1(y)$ to maximize:

$$V_0(\bar{v}_0) = \sum_Y [(y - w_0(y)) + \beta V_1(v_1(y))] f(y; e_0) \tag{First Period}$$

subject to

$$\sum_Y [u(w_0(y), e_0) + \beta v_1(y)] f(y; e_0) \geq \sum_Y [u(w_0(y), e') + \beta v_1(y)] f(y; e') \text{ for all } e' \in E, \tag{3}$$

$$\sum_Y [u(w_0(y), e_0) + \beta v_1(y)] f(y; e_0) = \bar{v}_0, \tag{4}$$

where $\bar{v}_0$ is the utility of an exogenously given outside option.

We assume that $E = \{0, 1\}$ and that $Y = \{y_L, y_H\}$, with $y_H > y_L > 0$. As in Jensen and Murphy (1990) and Wang (1997), y_t can also be interpreted as a measure of current performance at time t, such as net firm income before executive compensation, while V_t can be interpreted as shareholder wealth at time t and corresponds to the neoclassical notion of firm value.

3.1.1 Modelling Executives' Impact and Effectiveness

In this section, we enrich the structure of the model to allow for variable firm size and variable executive productivity. We assume that output, y, is a function of firm capital, K, firm productivity θ, and the executive officer's productivity, τ:

$$y = \theta \left(\tau^{\phi}\right) K, \tag{5}$$

where $\theta \in \Theta = [\theta_L, \theta_H]$, so that $y_j = \theta_j \left(\tau^{\phi}\right) K$ for $j = L, H$. We interpret K as firm size. The parameter $\phi \in (0, 1)$ indexes the elasticity of firm profits to an executive's productivity. We assume that K, τ and θ, as well y, are observable. Then, $\Pr(y_j | e) = \Pr(\theta_j | e)$ for $j = L, H$, and we can denote with $f(\cdot; e)$ the conditional probability of θ. We assume that the executive's effort influences the probability distribution of the shock θ, and therefore of output, as follows:

$$f(\theta_H; e) = a + be, \tag{6}$$

for $a > 0$ and $b > 0$, and $a + b \leq 1$, and $\sum_j f(\theta_j; e) = 1$

We identify an executive officer's *effectiveness* with the executive's productivity, τ[6]. We identify the *impact* of an executive officer on firm performance as the increase in the expected value of y resulting from the executive choosing high effort. This is given by:

$$E(y|e=1) - E(y|e=0) = [f(\theta_H; 1) - f(\theta_H; 0)](y_H - y_L). \quad (7)$$

As equation (7) makes clear, this depends on two components. The first, which we refer to as *probability-impact,* corresponds to the effect of an increase in effort on the probability of high realized performance, the parameter b. The second is the spread in y across the high and low productivity states, which depends on the difference between θ_H and θ_L. We refer to the ratio θ_H/θ_L as *productivity-impact.*

We study the optimal fraction of incentive pay, the optimal fraction of delayed compensation and pay-performance sensitivities of the optimal contract as a function of the executive officer's effectiveness and their probability- and productivity-impact.

3.2 Numerical Findings

To evaluate whether the "low effectiveness" or the "low impact" hypothesis are more plausible for modelling female top executives, we conduct some numerical simulations.

First, we fix effectiveness and compute the optimal contract for different values of impact, altering both the probability-impact, the parameter b, and the productivity-impact, the ratio y_H/y_L. Second, we fix impact and study the optimal contract for different levels of effectiveness, the parameter τ. We repeat this exercise for different firm sizes. In all the simulations we set initial promised utilities so that shareholders are indifferent between executives with different impact/effectiveness.

We use the following specification for preferences:

$$u(c, e) = \frac{c^{1-\sigma}}{1-\sigma} - \gamma e, \quad (8)$$

where $\sigma, \gamma > 0$. We analyze the following numerical example: $\sigma = 1.5$, $\gamma = 0.3$, $\beta = 0.9$, $\phi = 0.8$, $a = 0.5$, for $K = 1.6$ and $\tau = 1$. The values of v_0 are set to maintain shareholder wealth constant[7] at $V_0 = 0.3705$, reported in units of consumption[8]. We select the target profit

[6] Given that the executive's utility is separable in consumption and effort, this specification is isomorphic to one in which the executives differ in the utility cost of effort. Higher values of τ would correspond to lower values of the utility cost of effort.

[7] We first characterize the optimal contract on a grid for v_0 for the different impact/effectiveness levels. We set a target profit level for the highest impact/effectiveness. We choose the higher possible value of v_0 on the grid at the lower impact/effectiveness such that V_0 is greater than or equal to target profit level for the highest impact/effectiveness.

[8] Based on $e_0 = 0$, initial promised utility in units of consumption is simply given by the inverse of the function u evaluated at $v_0/(1+\beta)$. Based on $e_1 = 0$, continuation utility in units of consumption is given by the inverse of the function u evaluated at $v_1(y_j)$, $j = L, H$.

level so that high effort is implemented for all levels of impact/effectiveness considered at the corresponding value of v_0.

We first examine the sensitivity of optimal compensation contracts to probability- and productivity-impact. The following table displays the results for *probability-impact*, for $\Theta = [0.08, 0.3]$. The last four rows of the table present the model counterpart of the data statistics discussed in the previous section.

The first statistic "salary/tcc" corresponds to the ratio:

$$\frac{w_0(y_L)}{w_0(y_L) + f(\theta_H; 1)(w_0(y_H) - w_0(y_L))},$$

in the model, where $w_0(y_L)$ is the base salary and $w_0(y_L) + f(\theta_H; 1)(w_0(y_H) - w_0(y_L))$ is the expected current compensation (salary + bonus). The "salary/tdc" statistic corresponds to the ratio

$$\frac{w_0(y_L)}{w_0(y_L) + f(\theta_H; 1)(w_0(y_H) - w_0(y_L)) + v_1(y_L) + f(\theta_H; 1)(v_1(y_H) - v_1(y_L))},$$

in the model, where the quantity:

$$w_0(y_L) + f(\theta_H; 1)(w_0(y_H) - w_0(y_L)) + v_1(y_L) + f(\theta_H; 1)(v_1(y_H) - v_1(y_L)),$$

is the expected total compensation (current and delayed.). The model counterpart for the delayed share of total compensation, "dc/tdc", is given by:

$$\frac{v_1(y_L) + f(\theta_H; 1)(v_1(y_H) - v_1(y_L))}{w_0(y_L) + f(\theta_H; 1)(w_0(y_H) - w_0(y_L)) + v_1(y_L) + f(\theta_H; 1)(v_1(y_H) - v_1(y_L))},$$

where the numerator corresponds to expected delayed compensation. Finally, *pay-performance sensitivity* in the model is given by the ratio $\frac{(w_0(y_H) - w_0(y_L))}{y_H - y_L}$.

b	0.10	0.25
v_0 in units of consumption	0.039	0.089
$w_0(y_L)$	0.060	0.092
$(w_0(y_H)/w_0(y_L) - 1)\,\%$	28.62	7.64
$v_1(y_L)$ in units of consumption	0.021	0.071
$(v_1(y_H)/v_1(y_L) - 1)\,\%$	42.57	36.10
"*salary/tcc*"	*0.853*	*0.946*
"*salary/tdc*"	*0.623*	*0.489*
"*dc/tdc*"	*0.270*	*0.482*
"pay-performance sensitivity"	*0.049*	*0.019*

We find that:

- The salary share of current compensation is increasing in impact. The fraction of base pay in delayed compensation is decreasing in impact.
- The share of delayed compensation is increasing in impact.
- Pay-performance sensitivity is declining in impact.

Note that in this exercise a higher value of the parameter b corresponds to a higher value of the probability of a good outcome given high effort ($f(\theta_H; 1)$). This implies that the share of delayed compensation is higher for greater *probability-impact* since for a given percentage bonus the probability of receiving it is higher.

The following table displays results for *productivity-impact*. We set $b = 0.25$, and vary θ_H and θ_L, keeping the expected value of θ conditional on high effort fixed. This corresponds to a mean-preserving spread of productivity. The last four rows of the table present the model counterpart of the data statistics discussed in the previous section.

θ_H/θ_L	1.59	2.28
θ_L	0.170	0.125
v_0 in units of consumption	0.101	0.099
$w_0(y_L)$	0.135	0.135
$(w_0(y_H)/w_0(y_L) - 1)\,\%$	16.10	16.43
$v_1(y_L)$ in units of consumption	0.064	0.063
$(v_1(y_H)/v_1(y_L) - 1)\,\%$	27.34	26.72
"*salary/tcc*"	*0.892*	*0.890*
"*salary/tdc*"	*0.590*	*0.594*
"*dc/tdc*"	*0.338*	*0.333*
"pay-performance sensitivity"	*0.135*	*0.087*

We find that:

- The salary share of incentive pay is not very responsive to productivity-impact.
- The fraction of delayed compensation slightly declines in productivity-impact.
- Pay performance sensitivity is decreasing in productivity-impact.

An increase in productivity-impact corresponds to an increase in the volatility of profits, since the expected value of profits is maintained constant. Increasing volatility of profits increases the severity of the incentive problem as well as increasing the value of the executive (and her ability to exert high effort) for the firm. The latter effect, which tends to increase the "power of incentives" (e.g. the fraction of incentive pay) seems to prevail. The presence of the opposing effects may account for the small sensitivity of optimal contracts to productivity-impact.

We now examine the role of effectiveness, the parameter τ. We set $\Theta = [0.08, 0.3]$, $b = 0.25$. We consider different values of K, which corresponds to firm size in our model. The following table displays the results for $K = 1.3$ and for $K = 1.6$. The last four rows of the table present the model counterpart of the data statistics discussed in the previous section.

	$K = 1.3$		$K = 1.6$	
τ	1	1.3	1	1.3
v_0 in units of consumption	0.039	0.111	0.0344	0.1154
$w_0(y_L)$	0.057	0.099	0.0554	0.1199
$(w_0(y_H)/w_0(y_L) - 1)\,\%$	7.193	7.460	8.4239	10.9173
$v_1(y_L)$ in units of consumption	0.024	0.099	0.0205	0.0897
$(v_1(y_H)/v_1(y_L) - 1)\,\%$	17.89	45.59	15.2768	38.7895
"*salary/tcc*"	*0.949*	*0.947*	*0.941*	*0.924*
"*salary/tdc*"	*0.653*	*0.416*	*0.678*	*0.488*
"*dc/tdc*"	*0.237*	*0.464*	*0.279*	*0.488*
"pay-performance sensitivity"	*0.014*	*0.019*	*0.013*	*0.035*

We find that:

- The salary share of total compensation is decreasing in effectiveness. The decrease is largest for the definition of total compensation that also include delayed pay.
- The share of delayed compensation is increasing in effectiveness.
- Pay performance sensitivity is increasing in effectiveness.

This findings are not sensitive to firm size. We also find that, for given effectiveness: i) pay-performance sensitivities are increasing in firm size for high effectiveness; ii) the salary share of current compensation is decreasing in firm size; iii) the share of delayed compensation is increasing in firm size.

4 Female Executives: Lower Impact or Lower Effectiveness?

Our preliminary analysis shows that:

- Modelling female executives as having *lower impact* is not consistent with the empirical evidence. This is because the salary share of current compensation is increasing in impact and pay performance sensitivities are declining in impact. These two predictions are in contrast with the pattern found in the data.

- Modelling female executives as having *lower effectiveness* is consistent with the empirical evidence. We find that: (i) the salary share of total compensation is decreasing in effectiveness; (ii) the decrease is largest for the definition of total compensation that also include delayed pay; (iii) the share of delayed compensation is increasing in effectiveness; (iv) pay-performance sensitivity is increasing in effectiveness.

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5 Data Appendix

Our sample is built according to the following criteria:

1. All observations with missing executive-firm IDs (Compustat variable CO_PER_R) are deleted.

2. All observations from fiscal years 2005 or above are deleted.

3. All "retired" executives are deleted. Executives are considered to be retired if any of the following words appear in the modified TITLEANN (see below): "former", "retired", "ret.", "emeritus".

4. Whenever an executive has observations with non-consecutive years, all observations for that executive are deleted.

Job "Titles" We construct the job "title" variable as follows:

a. The dataset has two title variables – TITLE, which shows the most recent title, and TITLEANN, which shows the title in a given fiscal year. The former has less than 300 missing values, while the latter has almost 40,000. The two variables have discrepancies even in the most recent year. TITLEANN is used as the basis of all title variables. However, whenever it is missing in the most recent year, TITLE is used. The resulting combined variable has approximately 4,000 missing values.

b. Titles are classified according to specific key words that appear in the (modified) TITLEANN from a.. However, whenever a semicolon appears in TITLEANN, only the portion of the title that precedes the semicolon is used.

c. Titles are grouped into the following eleven categories:

Chairman and/or CEO
Vice Chairman
President
Chief Financial Officer
Chief Operating Officer
Other Chief Officer
Executive Vice President
Senior Vice President
Group Vice President
Vice President
Other

These categories correspond to categories used by Bertrand and Hallock (2001). The titles are listed in the order of perceived importance. Note that executives can hold multiple titles, but categorized titles show the highest title identified. Because the title categorization is based on an *ad hoc* process of searching for specific key words, it is necessarily imprecise. For a detailed list of key words used to identify each title, see Table A4. See Table A2 for a break down of the incidence of job titles by gender.

d. Some executives hold offices in subsidiary companies, as opposed or in addition to the parent company actually listed in the dataset. The presence of such subsidiary positions presents a serious problem for accurate title classification. We also construct an alternative variable that groups "titles" in 16 categories in order to take into account executive positions in subsidiaries. Executives who hold Chair/CEO, Vice Chair, President, or COO positions in a subsidiary company only were identified using the following method:

i. Dashes that appear to be part of title key word (e.g., V-P) were replaced with other characters.

ii. Remaining dashes were interpreted as indicators that the title includes the name of the subsidiary company. Abovementioned titles were then reclassified as subsidiary titles, e.g., President sub.

The results of the analysis do not change when we use this alternative definition for job "titles".

e. It should be noted that there are also instances of shared positions, e.g., Co-CEOs. In all classifications the "co-" prefix is ignored and such executives are treated like full CEOs, etc. There are also instances of multiple executives within a firm and year with the same title. Again, no special treatment is given to such observations.

The results of our regression analysis do not change when we use this alternative definition of job "titles". Hence, we do not report them in the paper.

Department Based on a priori assumptions and a frequency analysis of titles of female executives, three specific departments were identified (again based on key words in the title) – Human Resources, Marketing, and Administrative. The key words used for HR are "human," "HR," and "people." The key words for Marketing are "marketing" and "advertising." Titles with the word "admin" are classified as Administrative. Table A5 summarizes the distribution of executives across departments by gender. The T-Tests in column 3 show that the incidence of departments is statistically different by gender. We also run our regressions for a specification that includes dummy variables for both job-titles and department. The results are unchanged relative to the ones reported in the paper.

Table A1
Summary Statistics

	FEMALES			MALES		
	Mean	Std Dev.	Obs	Mean	Std. Dev.	Obs
TCC	473	525.9	6560	659	1032.7	133120
TDC1	1456	3209.3	4993	2045	6270.1	112744
TDC2	1032	2649.6	6560	1682	6390.2	133120
DC	871	2812.4	4993	1221	5526.3	112744
SALES	3497	8316.7	6542	4128	11566.6	132737
EMPLOYEES	17.4	49.0	6367	17.9	49.1	129423
MKTVAL	5055	15957	6378	5707.9	19753.5	130334
Salary/TCC	0.70	0.20	6555	0.68	0.22	132755
Salary/TDC1	0.41	0.25	4992	0.40	0.25	112631
Salary/TDC2	0.54	0.27	6558	0.50	0.27	132952
Delayed/TDC1	0.37	0.28	4992	0.36	0.28	112631
AGE	49.5	7.2	574	52.2	7.9	16627
TENURE	7.4	8.1	1955	11.0	11.0	39266

Table A2
Incidence of Job Titles by Gender
(percentage values, columns 1 and 2 add to 100)

	FEMALES	MALES	T-test Statistics	p-values
Chair/CEO	6.04	23.18	-32.66	5.1E-23
Vice Chair	2.44	3.05	-2.82	0.0047
President	10.44	12.99	-6.01	1.8E-09
CFO	12.42	10.57	4.74	2.1E-06
COO	1.46	2.17	-3.87	0.0001
Other Chief	7.79	4.63	11.70	1.2E-31
Exec VP	16.63	13.34	7.62	2.6E-14
Senior VP	19.22	12.91	14.75	3.2E-49
Group VP	0.43	0.8	-3.36	0.0008
VP	17.45	12.21	12.56	3.6E-36
Other	2.12	1.42	4.64	3.4E-06
Missing	3.55	2.72	4.02	5.9E-05

Table A3
Distribution of "Years-to-Payment": Long-Term Incentive Payout (LTIP) and Stock Options Granted

	Column (i): LTIP			Column (ii): Stock Options Granted	
Years	FEMALES	MALES	Years	FEMALES	MALES
1	1.31	2.3	0	0.36	0.2
2	6.75	8.26	1	0.39	0.29
3	77.86	72.17	2	0.26	0.24
4	9.38	10.25	3	0.46	0.42
5	3.38	5.4	4	0.72	1.01
6	0.94	0.85	5	4.43	4.82
7	0	0.18	6	1.64	1.61
8	0	0.08	7	3.38	3.12
9	0	0.01	8	1.08	1.13
10	0.19	0.49	9	9.31	10.22
11	0	0.01	10	74.45	73.42
14	0	0.01	11	2.98	2.75
			12	0.13	0.11
			13	0.03	0.03
			14	0.03	0.05
			15	0.2	0.27
			16	0.1	0.04
			>=17	0.8	0.76

Notes: Column (i): Distribution over years in the future the executive will receive the payout under the long-term incentive plan. Column (ii): Distribution over years until expiration of stock options granted to executive. Entries in the table are percentage values.

Table A4
Key Words Used in Identifying "Job Titles"

TITLE	KEY WORDS
Chair/CEO	CHAIRMAN & CHAIR CHMN CEO CHIEF EXECUTIVE OFFICER
Vice Chair	VICE CHAIR VICE-CHAIR V-CHAIR V-CHMN VCHMN VICE CHMN VICE-CHMN
President	PRESIDENT

	PRES. PRES& PRES
CFO	CFO CHIEF FINANCE OFFICER CHIEF FINANCIAL OFFICER
COO	COO CHIEF OPERATING OFFICER CHIEF OPERATION OFFICER CHIEF OPERATIONS OFFICER
Other Chief	CHIEF CHF
Exec VP	EXECUTIVE VP EXECUTIVE V-P EXEC V.P. EXEC V-P EXEC. V-P EXEC. V-P EXEC.V-P EXEC.VP EXEC VP EXEC. VP
Sr VP	SENIOR VP SENIOR V-P SR V-P SR. V-P SR.V-P SR.VP SR VP SR. VP
Group VP	GROUP VP GROUP V-P
VP	VP V-P
Other	All uncategorized titles (where TITLEANN is not missing) plus ASSISTANT TO CHAIRMAN ASSISTANT TO CHMN ASSISTANT TO THE CHAIRMAN OFFICE OF THE CHAIRMAN ASSISTANT TO CEO ASSISTANT TO THE CEO ASSISTANT TO PRES ASSISTANT TO THE PRES EXEC. CEO-ASSISTANT

Table A5
Incidence of Departments by Gender
(percentage values, columns 1 and 2 add to 100)

	FEMALES	MALES	T-test Statistics	p-values
HR	5.88	0.93	36.62	3.87E-29
Marketing	2.76	1.75	6.00	1.93E-09
Admin	3.23	1.78	8.53	1.43E-17
Other	84.57	92.82	-24.69	2.52E-13
missing	3.56	2.72	4.02	5.9E-05