

# **Optimal CEO Compensation with Search: Theory and Empirical Evidence**

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# 1. Motivation: two puzzles on executive compensation

Puzzle One: relation between firm's risk and pay-to-performance sensitivity (PPS).

Standard principal-agent theory:

For a risk-neutral CEO:

PPS=1 (not affected by risk)

For a risk-averse CEO:

PPS is negatively affected by risk

Empirical evidence:

quite mixed

Core and Guay (1999):

positive

Aggarwal and Samwick (1999):

negative

## 1. Motivation: Puzzle two

	<u>1994</u>	<u>2009</u>
total pay (M\$)/firm value (B\$)	1.59	1.73
incentive pay/total pay	41%	78.8%

- Incentive pay has increased more rapidly than firm value;

1994 – 2009:	incentive pay	↑	244%
	firm value	↑	40%

The key is to understand this fact is to understand the pay-to-performance sensitivity (PPS).

## Two factors are important for PPS in a market economy:

- Job mobility:

Changes in market condition can affect PPS by affecting the degree of competition for CEOs.

- Risks:

Switching from one firm to another, a CEO can change the amount of firm-specific risk that he is exposed, but not that of systematic risk. Thus, PPS should depend on the two types risks different.

## Typical features of a standard principal-agent model:

- One firm and one CEO, hence no interactions among firms;
- Participation constraint is always satisfied;
- Exogenous reservation utility;
- Total firm risk.

## 2. Objective:

To study the effects of job mobility and two risks on incentive contracts in a market equilibrium where firms compete for CEOs.

Method:

Integrating a principal-agent model into search theory.

### 3. Contributions:

- To principal-agent literature:
  - ✓ Model CEO quitting behavior
  - ✓ Analyze the optimal compensation contract in a dynamic setting where firms compete for CEOs
- To labor search literature:
  - ✓ Introduce incentive contract into a standard labor search model
- To empirical executive compensation literature:
  - ✓ Clarify empirical specification and reconcile the mixed evidence on the relationship between PPS and firm risks

## Related literature

**Oyer (2004 JF): consider an agent who does not always participate**

- Lower ranked employee;
- No effort-inducing mechanism;
- Exogenous reservation utility;
- Not a market equilibrium model.



**Edmans, Gabaix and Landier (2009 RFS):** explain the negative relation between the executive's equity stake and firm size

- Positive assortitive assignment model
- Effects of risks are not the focus

## 4. Theoretical Model:

- *Aggregate risk (y):* *i.i.d*
- *Match-specific risk (x):* *independent of y*

- *Matching Function:*

$$m(v,u) = \frac{vs}{v+s}$$

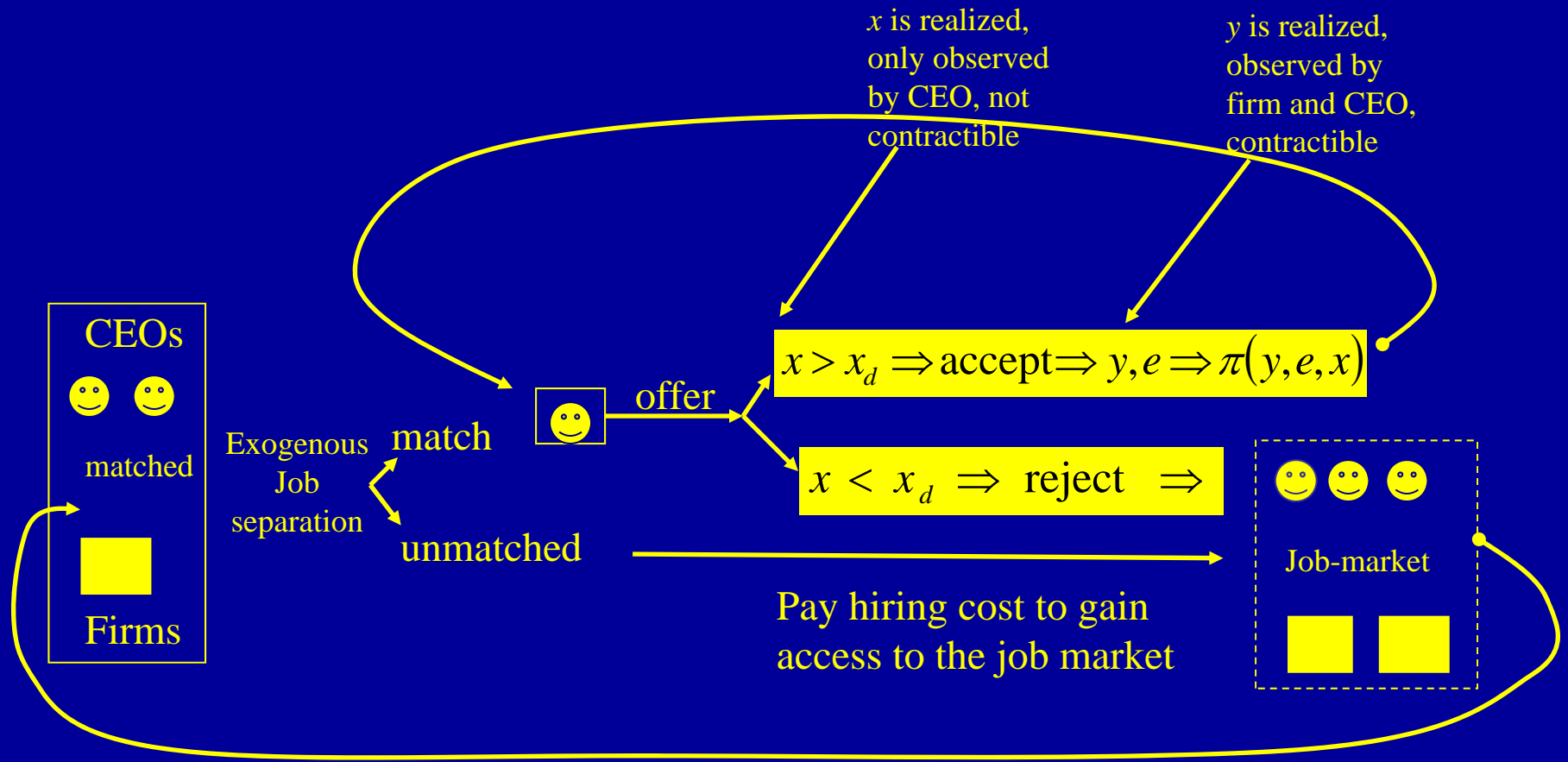
- *Profit function:*

$$\pi \equiv \pi(e, x, y) = ey^\alpha \sqrt{x}$$

- *CEO's period utility function*

$$u(W, e) = W - \frac{1}{2}ce^2$$

# 4. Theoretical Model



## 4. Theoretical Model: CEO's decisions

Compensation contract  $\Psi(a,b)$ :  $w = a + b \pi(e, x, y)$

CEO's optimal effort:  $e^*(\psi, x, y) = \frac{b}{c} y^\alpha x^{1/2}$

Hence,

$$\pi^*(\psi, x, y) = \frac{b}{c} y^{2\alpha} x$$

$$w^*(\psi, x, y) = a + b \pi^* = a + \frac{b^2}{c} y^{2\alpha} x$$

$$u^*(\psi, x, y) = w - \frac{c}{2} e^2 = a + \frac{b^2}{2c} y^{2\alpha} x$$

## 4. Theoretical Model: CEO's decisions

Value function of an employed CEO:

$$V_E = V_S + (1 - \delta) \int_{\bar{x}(\psi, u)}^{\bar{x}} E_y [u^*(\psi, x, y) - \underline{u}] dF_1(x)$$

Value function of a searching CEO:

$$V_S = B + [\lambda\beta V_{E,+1} + (1 - \lambda)\beta V_{S,+1}]$$

## 4. Theoretical Model : CEO's decisions

CEO's optimal acceptance decision:

$$E_y [u^*(\psi, x, y)] \geq \underline{u} \equiv V_S - \beta V_{E,+1}$$

CEO's effective  
outside option

That is,

$$x > \rho \bar{x} \quad \text{where}$$
$$\rho(\psi, x, y) = \frac{2c [\underline{u} - E_y a]}{x E_y (b^2 y^2)}$$

CEO accepts the contract only if the match quality is high enough.

## 4. Theoretical Model:

## Firm's decisions

Value function of a firm with a CEO:

$$J_F = J_H + (1 - \delta) \max_{\psi} \int_{\bar{x}(\psi, \underline{u})}^{\bar{x}} E_y [\pi^*(\psi, x, y) - w^*(\psi, x, y) - \underline{J}] dF_1(x)$$

where  $\underline{J} = J_H - \beta J_{F,+1}$

Firm's effective  
Outside option

Value function of a hiring firm:

$$J_H = -H + [q \beta J_{F,+1} + (1 - q) \beta J_{H,+1}]$$

## 4. Theoretical Model:

## Market equilibrium

Law of motion:

$$s_{+1} - s = (1 - s + \lambda s) \left[ \delta + (1 - \delta) F_1(\bar{x} \rho_{+1}) \right] - \lambda s$$

Equilibrium definition: stationary and symmetric

- i) Given  $(\Psi, \underline{u})$ , a CEO's effort and acceptance decisions are optimal;
- ii) Given the outside options  $(\underline{u}, \underline{J})$ , a firm's  $\Psi^*(\underline{u}, \underline{J}, y)$  solves the firm's maximization problem;
- iii) Value functions  $V_E, V_S, J_F, J_H$  as stated earlier, given the outside options  $(\underline{u}, \underline{J})$ ;
- iv) Free entry condition requires the benefit of hiring a CEO being equal to the cost of hiring;
- v) Plus symmetry and stationary requirements.



## 5. Main Results: optimal contract with fixed outside options

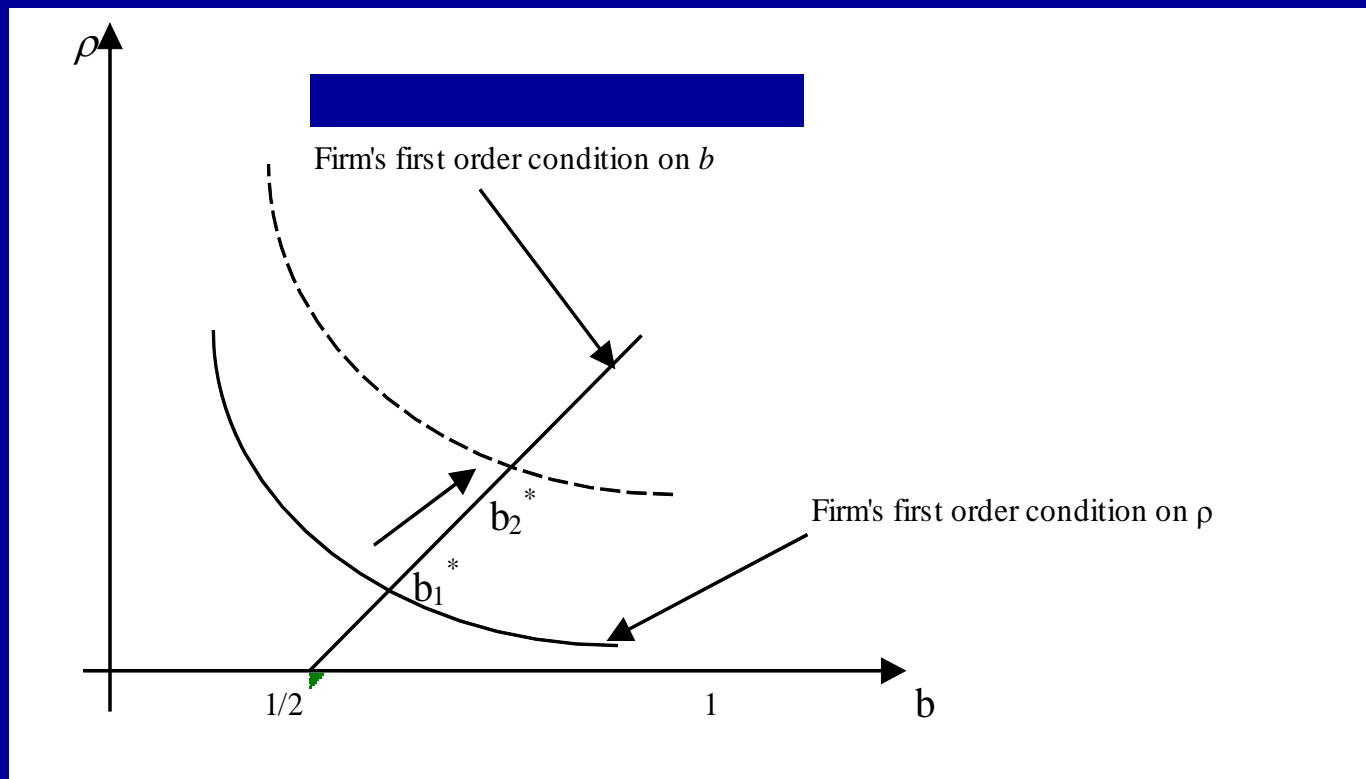
Lemma 3.1:

$$b^* = \frac{1}{3} + \frac{1}{3} \left[ 1 + \frac{3}{x\Omega} (\underline{u} + \underline{J}) \right]^{1/2}, \quad \rho = 2b^* - 1,$$
$$E_y a = \underline{u} - (b^*)^2 \rho \Omega, \quad \Omega \equiv \frac{1}{2c} \bar{x} E_y (y^{2\alpha}).$$

- $b^*$  and  $\rho$  are independent of  $y$ , they are complementary;
- $b^* < 1$ ;
- $b^*$  increases  $\underline{u} + \underline{J}$ .

## 4. Theoretical Model:

effect of  $\underline{u} + \underline{J}$



## 5. Main Results: optimal contract with fixed outside options

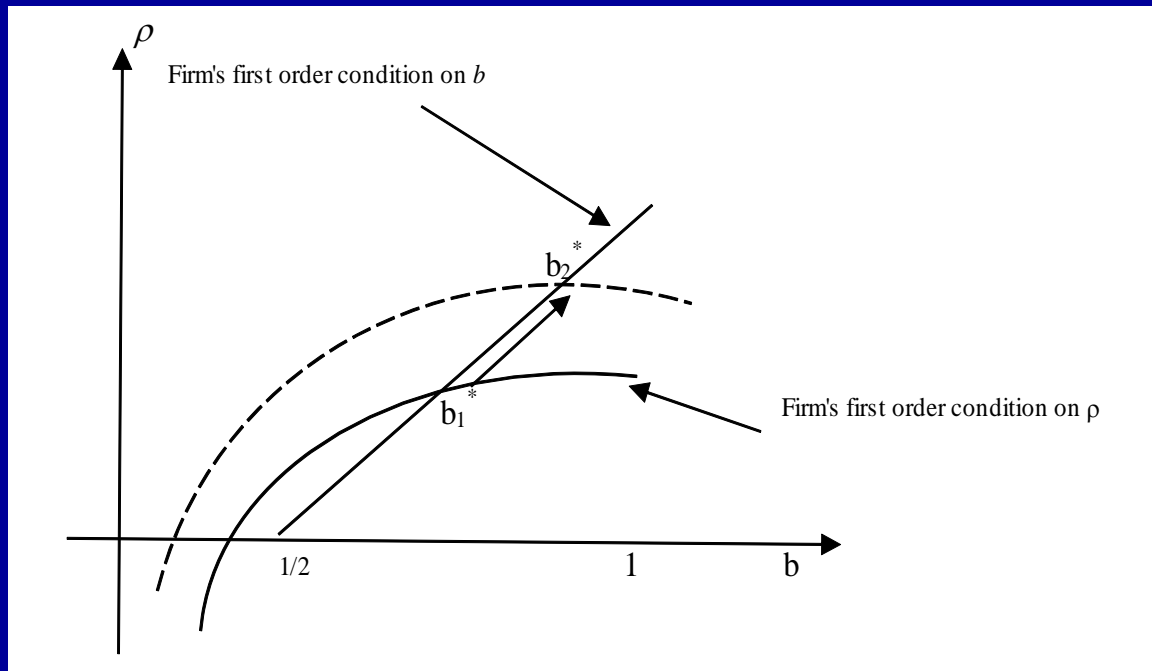
Proposition 3.2:

- $b^*$  decreases with  $\sigma_y$  and  $\sigma_x$  when  $\underline{u} + \underline{J} > 0$ , increases otherwise.

## 4. Theoretical Model:

effect of  $\sigma_x$  and  $\sigma_y$  through  $\Omega$

$$\Omega \equiv \frac{1}{2c} \bar{x} E_y (y^{2\alpha})$$



## 5. Main Results: contract externalities

- Two externalities:
  - $\underline{u}$  and  $\underline{J}$  increase with  $b$ .
  - $\underline{u}$  decreases with the matching probability  $q$ .

## 5. Main Results: properties of market equilibrium

Proposition 4.1: there exists a unique equilibrium with certain restriction on the model parameters. Two externalities:

- Equilibrium  $b^*$  decreases with  $\mu_y$  and  $\sigma_y$ ;
- Equilibrium  $b^*$  increases with  $\sigma_x$  for  $b^* < b_2$  (in the range of 2/3 to 1).

## 5. Main Results

Corollary 4.2: relative growth between total pay and firm size:

$$R_{pay/size} = \frac{E(a+b\pi)}{J_F} = \frac{2b}{1-b} + (1-b)L, \quad \frac{\partial R_{pay/size}}{\partial b} > 0$$

with  $L \equiv \beta(1-\delta)\bar{x}/(\sigma_x\sqrt{3})$

- Decrease with  $\mu_y$  and  $\sigma_y$ ;
- Increase with  $\sigma_x$  when  $b^* < b_2$  where  $b_2$  is in  $(2/3, 1)$ .

***Implication 1:***

**b: Pay-to-Performance Sensitivity**

↑ with firm specific risk,

↓ with aggregate productivity, firm systematic risk;

***Implication 2:***

**$R_{pay/size}$ : Relative growth between pay and size**

↑ with firm specific risk.

↓ with aggregate productivity, firm systematic risk,



## Empirical Proxies

<i>Aggregate</i>	Industry sale growth, GDP growth
<i>Productivity:</i>	Commercial paper spread, credit spread
<i>Firm Risks:</i>	Return Volatility (Core & Guay, 1999, JAE)
<i>Firm Size:</i>	Asset value or Market capitalization

## 6. Empirical Evidence:

## *PPS for new incentive*

	Prediction		OLS				Median			
	This Model									
Firm Idiosyncratic Risk	+	2.716 *** (10.574)	3.369 *** (12.284)	2.754 *** (10.719)	2.731 *** (10.650)	1.960 *** (14.341)	2.505 *** (17.313)	2.029 *** (14.878)	2.000 *** (14.521)	
Firm Systematic Risk	-	-1.105 *** (-2.823)	-0.924 ** (-2.365)	-1.259 *** (-3.214)	-1.192 *** (-3.044)	-0.735 *** (-4.090)	-0.574 *** (-3.025)	-0.843 *** (-4.671)	-0.778 *** (-4.272)	
Industry Sales Growth		-0.780 *** (-3.028)				-0.977 *** (-8.986)				
NCP Spread (basis points)			-0.020 *** (-12.497)				-0.011 *** (-15.718)			
GDP Growth				-11.787 *** (-7.906)				-10.179 *** (-15.534)		
NCredit Spread (basis points)					-0.007 *** (-9.553)				-0.006 *** (-18.150)	
CEO Age		-0.020 *** (-3.406)	-0.017 *** (-2.872)	-0.019 *** (-3.176)	-0.018 *** (-3.108)	-0.012 *** (-5.845)	-0.010 *** (-5.635)	-0.008 *** (-4.024)	-0.008 *** (-4.039)	
CEO Tenure		-0.012 ** (-2.258)	-0.014 ** (-2.577)	-0.012 ** (-2.256)	-0.012 ** (-2.273)	-0.007 *** (-3.780)	-0.008 *** (-4.274)	-0.007 *** (-3.507)	-0.006 *** (-3.230)	
log(Firm Size)		-0.383 *** (-15.142)	-0.361 *** (-14.230)	-0.391 *** (-15.456)	-0.395 *** (-15.621)	-0.206 *** (-24.534)	-0.188 *** (-20.656)	-0.208 *** (-22.991)	-0.208 *** (-23.582)	
Firm Growth		-0.017 (-0.119)	0.038 (0.269)	0.069 (0.483)	0.089 (0.623)	-0.003 (-0.045)	-0.028 (-0.475)	0.013 (0.212)	0.013 (0.223)	
Free Cash Flow		-1.614 *** (-2.749)	-1.541 *** (-2.623)	-1.695 *** (-2.892)	-1.709 *** (-2.916)	-1.242 *** (-5.153)	-1.167 *** (-4.968)	-1.228 *** (-4.843)	-1.321 *** (-5.563)	
Capital/Sales		-0.419 *** (-6.595)	-0.435 *** (-6.812)	-0.421 *** (-6.612)	-0.420 *** (-6.610)	-0.197 *** (-8.787)	-0.207 *** (-11.852)	-0.197 *** (-10.013)	-0.191 *** (-10.425)	
RD/Capital		0.035 (0.526)	0.005 (0.069)	0.011 (0.165)	-0.001 (-0.010)	0.165 *** (4.754)	0.128 *** (3.654)	0.138 *** (3.802)	0.114 *** (3.133)	
RD Missing Dummy		0.138 * (1.746)	0.159 ** (2.042)	0.135 * (1.713)	0.134 * (1.712)	0.027 (1.082)	0.041 (1.622)	0.024 (1.025)	0.014 (0.586)	
Advertising/Capital		0.011 (0.065)	0.023 (0.141)	0.028 (0.170)	0.033 (0.202)	0.023 (0.261)	0.069 (0.748)	0.034 (0.394)	0.032 (0.379)	
Advertising Missing Dummy		-0.040 (-0.541)	-0.057 (-0.779)	-0.011 (-0.157)	0.001 (0.018)	0.017 (0.658)	0.007 (0.270)	0.036 (1.440)	0.029 (1.220)	
Investment/Capital		0.326 (1.206)	0.079 (0.292)	0.388 (1.435)	0.422 (1.558)	0.114 (0.892)	-0.126 (-1.039)	0.134 (1.061)	0.199 (1.641)	
Adjusted or Pseudo R <sup>2</sup>		0.132	0.144	0.136	0.138	0.088	0.093	0.094	0.096	
		<b>Traditional Model</b>								
Firm Total Risk	-	2.057 *** (9.931)	2.718 *** (12.042)	2.038 *** (9.874)	2.043 *** (9.915)	1.466 *** (13.043)	1.976 *** (16.945)	1.432 *** (12.054)	1.446 *** (11.663)	
Adjusted or Pseudo R <sup>2</sup>		0.129	0.140	0.133	0.135	0.085	0.090	0.091	0.093	

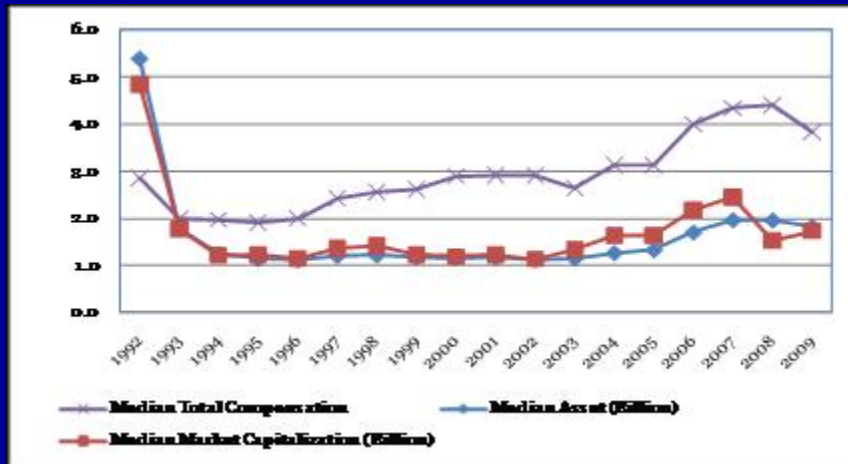
## Economic Magnitude (one std dev of the variable)

1. An increase of one std dev in firm specific risk (19%) increases the new equity incentive by \$459,237.
2. An increase of one std dev in firm systematic risk (10%) decreases the new equity incentive by \$98,673.

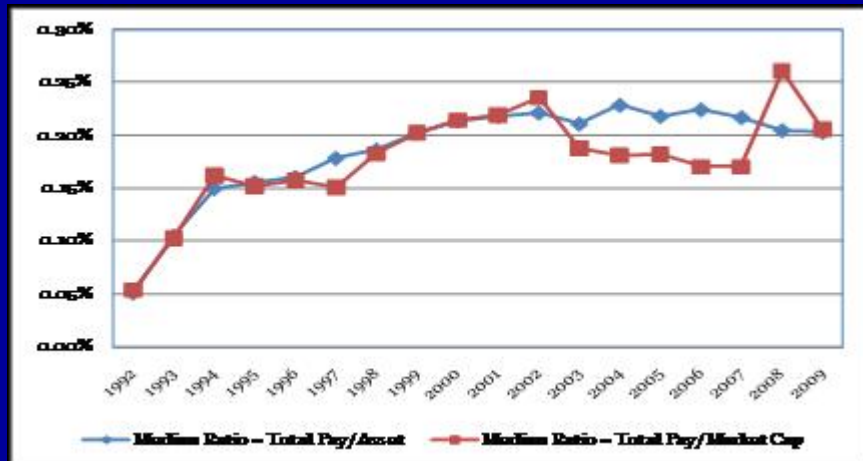
# 6. Empirical Evidence:

# Time Trend

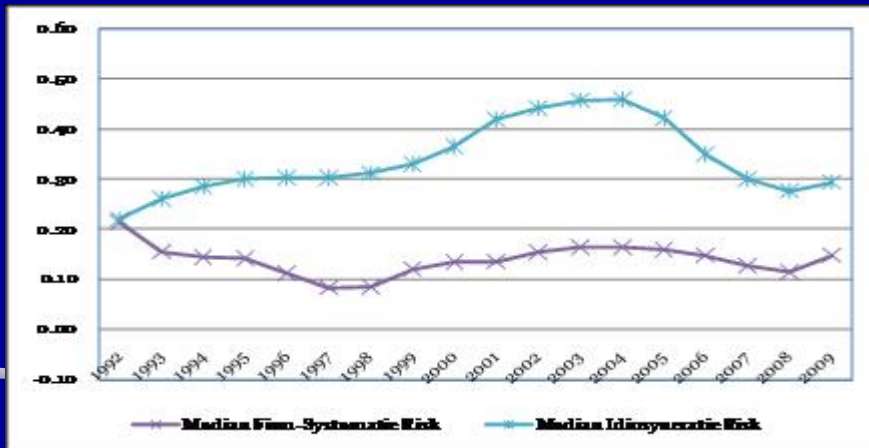
## Pay



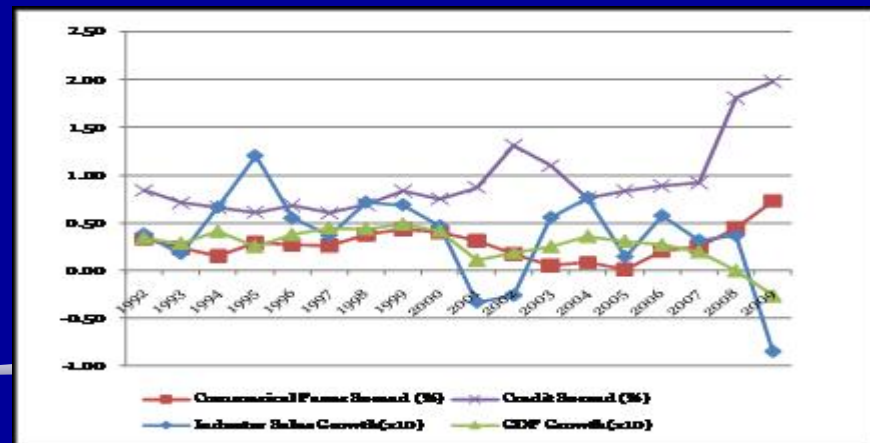
## Pay/Asset



## Risks



## Macro



## 6. Empirical Evidence:

## Ratio=Pay/Firm Size

Panel A: Rpay/size = Annual Total Pay/Sales (\$/a thousand \$)									
	Prediction	OLS				Median			
	This Model								
Firm Idiosyncratic Risk	+	12.660 *** (12.446)	13.493 *** (12.642)	12.668 *** (12.425)	12.660 *** (12.439)	6.388 *** (27.959)	6.837 *** (31.204)	6.428 *** (31.183)	6.398 *** (28.483)
Firm Systematic Risk	-	-8.487 *** (-5.507)	-8.094 *** (-5.317)	-8.522 *** (-5.519)	-8.495 *** (-5.518)	-3.402 *** (-10.277)	-3.404 *** (-10.049)	-3.776 *** (-11.799)	-3.585 *** (-11.097)
Industry Sales Growth		0.536 (0.842)				-0.574 *** (-3.018)			
NCP Spread (basis points)			-0.031 *** (-6.979)				-0.012 *** (-10.824)		
GDP Growth				-2.620 (-0.689)				-7.969 *** (-7.826)	
NCredit Spread (basis points)					-0.001 (-0.399)				-0.004 *** (-8.396)
CEO Age		-0.058 *** (-2.959)	-0.052 *** (-2.678)	-0.057 *** (-2.932)	-0.057 *** (-2.937)	-0.011 *** (-3.229)	-0.009 *** (-3.007)	-0.010 *** (-3.101)	-0.010 *** (-2.789)
CEO Tenure		0.046 *** (2.900)	0.043 *** (2.702)	0.046 *** (2.908)	0.046 *** (2.904)	0.014 *** (4.491)	0.015 *** (4.443)	0.016 *** (5.034)	0.016 *** (4.822)
Firm Growth		3.207 *** (5.959)	3.488 *** (6.515)	3.304 *** (6.160)	3.285 *** (6.178)	0.360 ** (2.494)	0.439 *** (2.986)	0.455 *** (3.027)	0.426 *** (2.979)
Free Cash Flow		-24.659 *** (-7.470)	-24.445 *** (-7.458)	-24.666 *** (-7.484)	-24.659 *** (-7.486)	-0.969 ** (-2.094)	-0.829 * (-1.827)	-0.953 ** (-2.067)	-1.024 ** (-2.146)
Capital/Sales		2.860 *** (8.018)	2.835 *** (7.939)	2.864 *** (8.009)	2.864 *** (8.011)	0.901 *** (14.726)	0.878 *** (15.302)	0.923 *** (14.617)	0.923 *** (15.036)
RD/Capital		3.401 *** (9.485)	3.337 *** (9.329)	3.395 *** (9.448)	3.397 *** (9.440)	2.613 *** (16.761)	2.578 *** (15.617)	2.635 *** (16.504)	2.597 *** (16.066)
RD Missing Dummy		-0.680 *** (-2.874)	-0.653 *** (-2.780)	-0.681 *** (-2.881)	-0.681 *** (-2.879)	0.055 (1.336)	0.082 ** (2.007)	0.045 (1.249)	0.048 (1.258)
Advertising/Capital		0.185 (0.304)	0.215 (0.355)	0.195 (0.321)	0.192 (0.316)	0.685 *** (4.098)	0.725 *** (4.726)	0.747 *** (4.871)	0.739 *** (4.952)
Advertising Missing Dummy		0.512 ** (2.475)	0.494 ** (2.390)	0.528 ** (2.545)	0.525 ** (2.524)	0.241 *** (5.328)	0.247 *** (5.510)	0.286 *** (6.704)	0.298 *** (6.853)
Investment/Capital		4.623 *** (4.985)	4.251 *** (4.600)	4.656 *** (5.025)	4.649 *** (5.011)	1.373 *** (6.206)	1.239 *** (5.706)	1.445 *** (6.571)	1.525 *** (6.814)
Adjusted or Pseudo R <sup>2</sup>		0.372	0.375	0.372	0.372	0.148	0.151	0.150	0.150
	<u>Alternative Model</u>								
Firm Total Risk		9.144 *** (11.132)	10.072 *** (11.499)	9.139 *** (11.121)	9.139 *** (11.118)	5.061 *** (25.847)	5.542 *** (25.741)	4.990 *** (25.282)	4.966 *** (25.190)
Adjusted or Pseudo R <sup>2</sup>		0.360	0.363	0.360	0.360	0.139	0.141	0.140	0.140

## Economic Magnitude (sample median ratio = $1.81 * 10^{-3}$ )

1. An increase of one std dev in firm specific risk (19%) increases the ratio by  $1.229 * 10^{-3}$ .
2. An increase of one std dev in firm systematic risk (10%) decreases the ratio by  $0.34 * 10^{-3}$ .

## 7. Conclusion

We show that, when match quality is only observed by CEOs and CEOs can quit, the equilibrium incentive contract exhibits the following properties:

1. Pay-to-performance sensitivity is less than one for risk-neutral CEOs;
2. Systematic and firm-specific risks have opposite effects on the pay-to-performance. PPS increases with firm specific risk, decreases with systematic risk;
3. Ratio = total pay/firm size decrease with the expected aggregate state, firm systematic risk, increases with firm-specific risk.