Probability Weighting and Employee Stock Options

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01 Introduction

- This paper documents that riskier firms with higher idiosyncratic volatility grant more stock options to nonexecutive employees, while standard models in the literature cannot easily explain this pattern.

- Emphasizing the possibility that stock options are attractive to employees with “gambling preferences”.

- The key feature that makes stock options attractive is probability weighting. The model fits the data on option grants well when calibrated using standard parameters from the experimental literature.

- The results are the first evidence that risky firms can profitably use stock options to cater to an employee demand for long-shot bets.

02 The Model

- Variables

w	a take-it-or-leave-it offer of a pay contract made by a risk-neutral firm
T	time to maturity (the contract pays off in $t = T$)
P_T	the stock price at $t = T$
$F(P_T)$	the cumulative distribution function of the stock price P_T
ϕ	fixed salary
n_0	number of options
K	strike price

$w(P_T) = \phi + n_0 \max(P_T - K, 0)$

$P_T = P_0 \exp\left\{\left(r - \frac{\sigma^2}{2}\right)T + u\sigma\sqrt{T}\right\}$ where r, σ, u are risk-free rate, firm volatility, standard normally distributed random variable respectively.

02 The Model

■ Employee Preferences

The employee has preferences according to cumulative prospect theory (Tversky and Kahneman (1992)).

(1) An employee evaluates the risky payoffs from her compensation contract according to

$$E^{\psi}[v(w(P_T) - RP)] = \int v(w(P_T) - RP)d\psi\big(F(P_T)\big)$$

(2) The value function

$$v(w(P_T) - RP) = \begin{cases} (w(P_T) - RP)^{\alpha} & , \quad if\ w(P_T) \geq RP \quad (gain) \\ -\lambda\big(-(w(P_T) - RP)\big)^{\alpha}, & \quad if\ w(P_T) < RP\ (loss) \end{cases}$$

where $0 < \alpha \leq 1, \lambda \geq 1$, RP is a reference point.

If $\lambda > 1$, then employees dislike losses more than they are attracted by equal-sized gains.

02 The Model

■ Employee Preferences

(3) The probability weighting function transforms cumulative probabilities into decision weights via the function

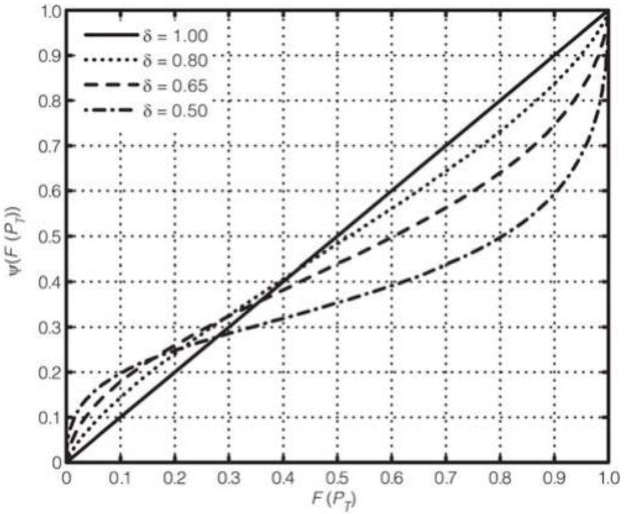
$$\psi\left(F(P_T)\right) = \begin{cases} \dfrac{-\left(1-F(P_T)\right)^{\delta}}{\left(F(P_T)^{\delta}+\left(1-F(P_T)\right)^{\delta}\right)^{\frac{1}{\delta}}}, & if\ w(P_T) \geq RP \\ \dfrac{F(P_T)^{\delta}}{\left(F(P_T)^{\delta}+\left(1-F(P_T)\right)^{\delta}\right)^{\frac{1}{\delta}}}, & if\ w(P_T) < RP \end{cases}$$

where $0.28 < \delta \leq 1$ measures the degree of probability weighting.

FIGURE 1

The Probability Weighting Function

Figure 1 shows the probability weighting function as proposed by Tversky and Kahneman (1992) for different values of the weighting parameter δ.



02 The Model

■ The Problem of the Firm

(4) Offer a compensation contract w such that the cost to the firm is minimized while providing the employee at least with her reservation value.

→ minimize compensation costs subject to the standard participation constraint of the employee

$$\min_{n_0,\phi} \phi e^{-rT} + n_0 BS$$

$$\text{s.t. } E^{\psi}[v(w(P_T) - RP)] \geq v(\bar{V} - RP),$$

$$n_0 \geq 0 .$$

$\bar{V}$ denotes the (nonnegative) outside opportunity of the employee, and $\bar{V}$ should be thought of as the certainty equivalent of a pay contract offered at another firm.

02 The Model

■ Assumption 1

The reference point RP, over a pay package of n_0 options and a fixed salary of ϕ, is linear in n_0 and ϕ and has the functional form

$$RP = n_0\theta + \phi$$

where θ represents any payoff expectation or aspiration level the employee holds for one option.

In this paper, we set θ as

- simplified intrinsic option value (the expected future stock price less the strike price of the option)

$$\theta = P_0 e^{rT} - K$$

- the Black-Scholes (1973) option value with maturity equal to T

$$\theta = BS$$

02 The Model

■ Proposition 1

Let BS be the Black-Scholes (1973) value of one option and CE denote the certainty equivalent the employee holds for one stock option, which is implicitly defined as

$$E^{\psi}\left[v\left(\max\left(P_T - K, 0\right) - \theta\right)\right] = v(CE\,e^{rt} - \theta)$$

Then the firm has a broad-based ESO plan if and only if $CE > BS$.

Proof:

- **Lemma 1** The prospect value of the contract (n_0, ϕ) does not depend on the base salary received and is homogeneous of degree α in the number of options n_0 if the reference point is given by $RP = n_0\theta + \phi$:

$$E^{\psi}(n_0, \phi) = E^{\psi}(n_0) = n_0^{\alpha} \times E^{\psi}(1)$$

- **Lemma 2** For any optimal contract (n_0^*, ϕ^*), the participation constraint is

$$E^{\psi}\left[v\left(n_0^*(\max(P_T - K, 0) - \theta)\right)\right] = v(\bar{V} - n_0^*\theta - \phi^*)$$

$$\rightarrow\ E^{\psi}\left[v\left(n_0^*\left(\max\left(P_T - K, 0\right) - \theta\right)\right)\right] \times v\left(\bar{V} - n_0^*\theta - \phi^*\right) \geq 0$$

02 The Model

$$v(w(P_T)-RP)=\begin{cases}(w(P_T)-RP)^{\alpha} & , \ if\ w(P_T)\geq RP \ \ (gain)\\ -\lambda\left(-(w(P_T)-RP)\right)^{\alpha} & , \ if\ w(P_T)< RP \ (loss)\end{cases}$$

- Proposition 1

<u>Case1</u> $E^{\psi}\left[v\left(n_0^*\left(\max\left(P_T-K,0\right)-\theta\right)\right)\right]\geq 0$

The certainty equivalent CE, which depends on both n_0^* and ϕ^*, is implicitly defined by

$$E^{\psi}\left[v\left(n_0^*(\max(P_T-K,0)-\theta)\right)\right]\equiv\overline{E^{\psi}(n_0^*)}$$
$$=(CE(n_0^*,\phi^*)e^{rT}-n_0^*\theta-\phi^*)^{\alpha}=(\bar{V}-n_0^*\theta-\phi^*)^{\alpha}$$

→ $CE(n_0^*,\phi^*)=\ \bar{V}e^{-rT}\ ,\ \bar{V}=\overline{E^{\psi}(n_0^*)}^{\frac{1}{\alpha}}+n_0^*\theta+\phi^*$

→ $CE(n_0^*,\phi^*)=\left(\overline{E^{\psi}(n_0^*)}^{\frac{1}{\alpha}}+n_0^*\theta+\phi^*\right)e^{-rT}=\overline{E^{\psi}(n_0^*)}^{\frac{1}{\alpha}}e^{-rT}+n_0^*\theta e^{-rT}+\phi^*e^{-rT}$

$$=n_0^*\times\overline{E^{\psi}\left(1\right)}^{\frac{1}{\alpha}}e^{-rT}+n_0^*\theta e^{-rT}+\phi^*e^{-rT}=n_0^*\times CE\left(1{,}0\right)+\phi^*e^{-rT}$$
$$=\bar{V}e^{-rT}$$

Thus, any contract that satisfies the original participation constraint must also satisfy $n_0^*\times CE(1{,}0)+\phi^*e^{-rT}=\bar{V}e^{-rT}$.

02 The Model

$$v(w(P_T) - RP) = \begin{cases} (w(P_T) - RP)^{\alpha} & , \ if\ w(P_T) \geq RP \quad (gain) \\ -\lambda\left(-(w(P_T) - RP)\right)^{\alpha}, & if\ w(P_T) < RP\ (loss) \end{cases}$$

- Proposition 1

<u>Case2</u> $E^{\psi}\left[v\left(n_0^*\left(\max\left(P_T - K, 0\right) - \theta\right)\right)\right] < 0$

The certainty equivalent CE, which depends on both n_0^* and ϕ^*, is implicitly defined by

$$E^{\psi}\left[v\left(n_0^*(\max(P_T - K, 0) - \theta)\right)\right] \equiv \overline{E^{\psi}(n_0^*)}$$

$$= -\lambda\left(-(CE(n_0^*, \phi^*)e^{rT} - n_0^*\theta - \phi^*)\right)^{\alpha} = -\lambda\left(-(\bar{V} - n_0^*\theta - \phi^*)\right)^{\alpha}$$

$$\rightarrow CE(n_0^*, \phi^*) = \bar{V}e^{-rT}, \bar{V} = -\left(-\frac{1}{\lambda}\overline{E^{\psi}(n_0^*)}\right)^{\frac{1}{\alpha}} + n_0^*\theta + \phi^*$$

$$\rightarrow CE(n_0^*, \phi^*) = \left(-\left(-\frac{1}{\lambda}\overline{E^{\psi}(n_0^*)}\right)^{\frac{1}{\alpha}} + n_0^*\theta + \phi^*\right)e^{-rT}$$

$$= -\left(-\frac{1}{\lambda}\overline{E^{\psi}(n_0^*)}\right)^{1/\alpha} e^{-rT} + n_0^*\theta e^{-rT} + \phi^* e^{-rT}$$

$$= n_0^* \times \left[-\left(-\frac{1}{\lambda}\overline{E^{\psi}(1)}\right)^{\frac{1}{\alpha}} + \theta\right]e^{-rT} + \phi^* e^{-rT} = n_0^* \times CE(1,0) + \phi^* e^{-rT}$$

$$= \bar{V}e^{-rT}$$

$$\rightarrow n_0^* \times CE(1,0) + \phi^* e^{-rT} = \bar{V}e^{-rT}$$

02 The Model

- Proposition 1

Case1 and Case2 have the result

$$\bar{V}e^{-rT} = n_0^* \times CE(1,0) + \phi^* e^{-rT} \rightarrow \phi^* e^{-rT} = \bar{V}e^{-rT} - n_0^* \times CE(1,0).$$

Combine it with model (4) $\min_{n_0,\phi} \phi e^{-rT} + n_0 BS$,

the problem becomes

$$\min_{n_0,\phi} \bar{V}e^{-rT} - n_0^* \times CE(1,0) + n_0^* BS = \min_{n_0} \bar{V}e^{-rT} - n_0^* \times (CE - BS)$$

If $CE > BS$, then $n_0^* > 0$ and $n_0^* = 0$ otherwise, which proves Proposition 1.

02 The Model

- Assumption 2

The costs limiting the size of the ESO plan can be described by a strictly increasing convex function $c(n_0)$, with $c(0) = 0$.

- Proposition 2

The number of stock options granted increases in $CE - BS$.

Proof:

Introducing a strictly convex cost function $c(n_0)$, the maximization problem becomes

$$\min_{n_0} \bar{V} e^{rT} - n_0^*(CE - BS) + c(n_0)$$

The 1st-order condition is $CE - BS = c'(n_0)$.

Since $c(\cdot)$ is strictly increasing, n_0 increases in $CE - BS$, which proves Proposition 2.

03 Calibration of the Model

- Parameter setting
  - $r = 5\%, T = 4\ years$ (Huddart and Lang (1996)), ESO is granted at the money
  - $\alpha = 0.88, \lambda = 2.25$
  - Assume risk-neutral pricing throughout

TABLE 2

Calibration Results

Table 2 presents the difference of certainty equivalent and the Black-Scholes (1973) value for one option, scaled by the share price P_0, for different combinations of probability weighting and firm volatility. The model predicts employee stock option plans if $CE > BS$ (cells with bold numbers in the table). Larger stock option grants are predicted for larger values of $CE - BS$. The calculations assume a lognormal stock price distribution with $T = 4$ years and $r = 5\%$. The strike price of the option, K, is set equal to the grant date stock price P_0. Preference parameters are $\alpha = 0.88$ and $\lambda = 2.25$. Panel A gives results when the reference point for one option is the Black-Scholes value (i.e., $\theta = BS$). Panel B gives results when the reference point for one option is $\theta = P_0e^{rT} - K$.

Probability Weighting	Firm Volatility									
δ	20%	25%	30%	35%	40%	45%	50%	60%	70%	80%
Panel A. $CE - BS$ Scaled by P_0 When $\theta = BS$										
0.40	**0.093**	**0.175**	**0.289**	**0.443**	**0.650**	**0.926**	**1.290**	**2.394**	**4.268**	**7.406**
0.50	**0.024**	**0.068**	**0.126**	**0.204**	**0.306**	**0.436**	**0.602**	**1.074**	**1.807**	**2.925**
0.60	−0.028	−0.012	**0.010**	**0.041**	**0.083**	**0.136**	**0.204**	**0.392**	**0.669**	**1.067**
0.63	−0.037	−0.028	−0.012	**0.010**	**0.041**	**0.081**	**0.133**	**0.276**	**0.488**	**0.790**
0.65	−0.045	−0.041	−0.032	−0.017	**0.004**	**0.033**	**0.070**	**0.176**	**0.334**	**0.559**
0.68	−0.048	−0.052	−0.049	−0.041	−0.028	−0.010	**0.016**	**0.091**	**0.204**	**0.367**
0.70	−0.052	−0.056	−0.059	−0.061	−0.056	−0.046	−0.031	**0.017**	**0.094**	**0.206**
0.75	−0.058	−0.065	−0.071	−0.076	−0.081	−0.085	−0.088	−0.091	−0.073	−0.035
0.80	−0.064	−0.073	−0.082	−0.091	−0.099	−0.107	−0.114	−0.126	−0.135	−0.141
0.90	−0.074	−0.088	−0.102	−0.117	−0.131	−0.146	−0.161	−0.191	−0.220	−0.249
1.00	−0.082	−0.100	−0.119	−0.138	−0.157	−0.177	−0.198	−0.240	−0.284	−0.327

03 Calibration of the Model

TABLE 2 (continued)

Calibration Results

Probability Weighting	Firm Volatility									
δ	20%	25%	30%	35%	40%	45%	50%	60%	70%	80%
Panel B. CE − BS Scaled by P_0 When $\boxed{\theta = P_0 e^{rT} - K}$										
0.40	**0.089**	**0.170**	**0.284**	**0.442**	**0.655**	**0.938**	**1.313**	**2.447**	**4.362**	**7.553**
0.50	**0.026**	**0.075**	**0.142**	**0.231**	**0.347**	**0.494**	**0.679**	**1.197**	**1.986**	**3.172**
0.60	−0.024	**0.000**	**0.036**	**0.083**	**0.143**	**0.217**	**0.308**	**0.550**	**0.890**	**1.359**
0.63	−0.035	−0.015	**0.014**	**0.053**	**0.103**	**0.165**	**0.240**	**0.438**	**0.713**	**1.086**
0.65	−0.044	−0.030	−0.007	**0.025**	**0.066**	**0.117**	**0.179**	**0.340**	**0.561**	**0.856**
0.68	−0.053	−0.043	−0.025	0.000	**0.033**	**0.074**	**0.124**	**0.254**	**0.430**	**0.662**
0.70	−0.060	−0.055	−0.043	−0.023	**0.002**	**0.035**	**0.075**	**0.178**	**0.316**	**0.497**
0.75	−0.071	−0.077	−0.073	−0.064	−0.051	−0.033	−0.010	**0.049**	**0.130**	**0.234**
0.80	−0.076	−0.094	−0.099	−0.099	−0.096	−0.089	−0.080	−0.053	−0.014	**0.036**
0.90	−0.084	−0.109	−0.135	−0.151	−0.164	−0.175	−0.185	−0.202	−0.216	−0.228
1.00	−0.092	−0.119	−0.146	−0.174	−0.202	−0.230	−0.253	−0.297	−0.341	−0.384

The results confirm the intuition: The more individuals overweight small probabilities (small δ) and the more small chances of large gains there are (large volatility), the more attractive options become.

04 Empirical Tests of the Model

Data

- data set: taken from the Center for Research in Security Prices (CRSP) Compustat merged database
  - ✓ drop all companies with fewer than 40 employees
  - ✓ drop all companies in the financial sector

  → Totally 14,612 firm-year observations for 2,228 unique firms
- sample period: 1992~2005
- estimate the number of options granted to nonexecutive employees
  - Broadly: all employees of the firm except those listed in ExecuComp
  - Narrow: correcting the total number of employees by the executives listed in ExecuComp and other high-ranking executives

Variables

- $\#\, ESO\ for\ nonexecutive\ =\ total\ ESO\ -\ \#ESO\ for\ high\ executive$
- $ESOPlan = 1_{\{\#granted\ options\ to\ nonexecutives\ in\ the\ firm-year\ >0\ and \geq 0.5\%\ of\ \#\ shares\ outstanding\}}$

04 Empirical Tests of the Model

Variable	Mean	SD	25th Pctl.	Median	75th Pctl.	*N*
Panel A. Firm Characteristics						
Employees	18,814	54,901	1,700	5,080	15,234	14,612
Sales ($m)	3,990	11,700	359	1,000	3,000	14,612
Volatility	46.28	21.66	30.35	41.26	57.58	14,612
Tobin's Q	2.11	1.48	1.21	1.60	2.39	14,612
R&D (in % of Assets)	3.82	7.21	0.00	0.18	5.04	14,612
Long-Term Debt > 0	86.70	33.96	100.00	100.00	100.00	14,612
$\ln(P_0)$	3.08	0.73	2.70	3.17	3.58	14,612
Dividend Yield	1.17	1.62	0.00	0.24	1.98	14,612
KZ-Index	0.22	1.20	−0.50	0.26	0.97	14,500
CF Shortfall	−0.18	0.15	−0.25	−0.17	−0.11	14,543
Interest Burden	0.10	1.38	0.04	0.11	0.20	13,306
New Economy Firm	16.03	36.69	0.00	0.00	0.00	14,612
Return($t-1$, t)	22.36	138.16	−14.90	8.98	37.55	14,584
Return($t-3$, $t-1$)	15.36	42.51	−7.25	9.59	29.72	13,795
Earnings volatility	96.53	252.87	29.97	49.48	81.54	11,025
Panel B. Stock Option Plan Characteristics						
Total granted options to shares outstanding	3.19	16.89	1.05	1.88	3.45	14,612
$\ln(1+n_o)$	3.22	3.02	0.00	3.62	5.72	14,612
ESOPlan	58.47	49.28	0.00	100.00	100.00	14,612
Percent of options to CEO	13.92	11.62	6.06	10.79	18.06	14,612
Percent of options to other reported executives	15.46	10.52	7.53	13.30	21.18	14,612
Percent of options to employees (broad)	70.62	18.91	60.15	74.26	85.00	14,612
Percent of options to employees (narrow)	42.83	28.48	18.20	45.47	66.37	14,612
BS-Value to CEO ('000)	1,417	2,536	193	544	1,426	14,612
BS-Value to other reported executives ('000)	447	778	73	183	463	14,612
BS-Value to employees (broad)	4,652	11,662	158	543	2,698	14,612
BS-Value to employees (narrow)	4,105	11,168	0	167	1,942	14,612
BS-Value to employees (broad) if $n_o > 0$	7,664	14,486	487	1,658	7,441	8,544
BS-Value to employees (narrow) if $n_o > 0$	7,020	13,887	316	1,212	6,547	8,544

04 Empirical Tests of the Model

TABLE 4

Sorting Results

Table 4 presents employee stock option (ESO) grants sorted by firm volatility. Volatility is the annualized total volatility computed from 3 years of daily stock returns. A firm has a broad-based stock option plan in the firm-year (ESOPlan = 1) if the number of nonexecutive ESOs is positive and greater than 0.5% of the number of shares outstanding. The per employee number of options is the number of options granted per nonexecutive employee. The number of nonexecutive employees are computed by correcting the total number of employees by the executives listed in ExecuComp and other high-ranking executives. The correction is based on estimating the total number of executives in a firm by taking the square root of the total number of employees. Nonexecutive employees are defined "broadly" as all employees of the firm except those listed in ExecuComp. Black-Scholes (1973) values are calculated based on the average of the grant date stock price reported in ExecuComp for all grants in a given firm-year. Maturity of the options and risk-free rate of interest are uniformly set to 7 years and 5%, respectively. The *t*-test and Wilcoxon rank-sum test are used to test the difference in the per employee number of granted options across adjacent quintiles.

Panel A. Mean

Firm Volatility Quintile	Firm Volatility	Percentage of Firms with ESO Plan	Per Empl. BS-Value	Per Empl. No. of Options	*t*-Test of Difference [*p*-value]	Per Empl. BS-Value (broad)	Per Empl. No. of Options (broad)
1	25.01%	41.14%	$353	63	—	$571	112
2	33.37%	46.85%	$989	124	0.00	$1,349	209
3	41.76%	52.89%	$1,731	213	0.00	$2,206	289
4	54.29%	68.00%	$4,448	526	0.00	$5,175	787
5	77.10%	83.57%	$13,032	1,967	0.00	$13,987	2,741

Panel B. Median

Firm Volatility Quintile	Firm Volatility	ESO Plan at Median Firm	Per Empl. BS-Value	Per Empl. No. of Options	Wilcoxon Test of Difference [*p*-value]	Per Empl. BS-Value (broad)	Per Empl. No. of Options (broad)
1	23.88%	No	$0	0	—	$201	55
2	31.35%	No	$0	0	0.00	$279	55
3	39.39%	Yes	$71	17	0.00	$456	76
4	52.05%	Yes	$564	97	0.00	$1,089	176
5	72.66%	Yes	$4,844	842	0.00	$5,670	989

Goal: show the hypotheses from the calibration model

1. higher-volatility firms should be more likely to have a broad-based stock option plan.
2. riskier firms should grant more ESOs
3. stock option grants increase in the degree of probability weighting.

04 Empirical Tests of the Model

associated with a greater likelihood of a broad-based stock option plan:

- Higher firm volatility
- Small firm
- High Tobin's Q
- High R&D expenditures

The negative coefficient on cash flow shortfall indicates that less cash-constrained firms are more likely to grant stock options.

TABLE 5

Existence of ESO Plans

Table 5 presents regressions of an indicator variable for the existence of a broad-based employee stock option plan on firm volatility and control variables. ESOPlan is equal to 1 if there is a broad-based stock option plan at the firm in the respective firm-year. Volatility is the annualized total volatility computed from 3 years of daily stock returns. All variables have been previously defined in Table 3. Industry dummy variables are based on the 3-digit SIC code. Marginal effects computed at the mean are reported for the probit models. Robust *t*-statistics (for the LPM) and *z*-statistics (for the probit model) with clustering at the firm level are given below the coefficient estimates.

	Dependent Variable							
	ESOPlan (dummy variable)							
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Probit
Volatility	0.244	0.262	0.229	0.245	0.233	0.272	0.190	0.244
	3.61	3.51	4.38	4.26	3.23	2.95	2.48	2.54
ln(Sales)	−0.010	−0.008	−0.017	−0.015	−0.006	0.002	−0.005	−0.009
	−1.39	−1.11	−2.96	−2.37	−0.75	0.27	−0.61	−0.92
Tobin's Q	0.012	0.010	0.012	0.015	0.010	0.008	0.000	0.002
	2.51	1.79	2.99	3.05	1.52	0.89	−0.02	0.14
R&D	0.382	0.695	0.349	0.401	0.517	0.821	0.809	2.867
	2.68	4.55	2.99	3.03	3.04	4.05	4.65	6.04
Long-Term Debt > 0	−0.022	−0.011	−0.016	−0.024	−0.045	−0.029	−0.009	−0.065
	−1.14	−0.54	−1.01	−1.40	−2.04	−1.00	−0.37	−1.68
KZ-Index	−0.004					0.002	−0.010	0.003
	−0.54					0.20	−0.99	0.27
CF Shortfall		−0.212				−0.228	−0.271	−0.300
		−3.46				−2.89	−3.86	−2.88
Interest Burden		−0.002				−0.002	0.011	0.000
		−0.66				−0.41	1.28	−0.09
New Economy Firm			0.159			0.161	0.102	0.296
			3.45			2.54	1.53	3.72
Return($t-1, t$)				−0.005		−0.004	−0.008	−0.022
				−2.02		−0.40	−0.80	−1.57
Return($t-3, t-1$)				−0.005		−0.037	−0.046	−0.055
				−0.58		−1.83	−2.40	−2.24
Earnings volatility					0.003	0.004	0.003	0.010
					1.72	2.13	1.41	2.12
Industry dummies							Yes	Yes
Year dummies								Yes
MSA × Year dummies							Yes	
Industry × Year dummies	Yes	Yes	Yes	Yes	Yes	Yes		
Pseudo/Adj. R^2	0.286	0.276	0.283	0.278	0.248	0.260	0.284	0.232
N	10,716	9,800	14,612	13,795	11,025	7,936	7,713	7,826

04 Empirical Test of the Model

- riskier firms grant more ESOs

TABLE 6

Size of Option Grants

Table 6 presents regressions of the number of employee stock options (ESOs) on firm volatility. All variables have been previously defined in Table 3. "Heckman's Lambda" is a self-selection variable from a 1st-stage probit model. Industry dummy variables are based on the 3-digit SIC code. Marginal effects computed at the mean for firms with ESO plans are reported for the Tobit model. Robust *t*-statistics (for the OLS model) and *z*-statistics (for the Tobit model) with clustering at the firm level are given below the coefficient estimates.

	Dependent Variable								
	$\ln(1 + n_O)$								
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Tobit
Volatility	1.796 8.22	1.742 6.95	1.629 9.05	1.491 7.36	1.059 4.35	1.483 4.72	1.166 4.65	0.705 3.15	0.696 3.89
ln(Sales)	−0.031 −1.17	−0.061 −2.06	−0.077 −3.38	−0.065 −2.68	−0.036 −1.30	−0.046 −1.36	−0.126 −4.22	−0.174 −2.78	−0.030 −1.56
Tobin's Q	0.153 8.61	0.172 8.77	0.173 11.74	0.213 11.34	0.197 9.24	0.207 6.85	0.193 7.36	0.097 4.87	0.051 2.65
R&D	1.173 1.87	2.036 3.17	0.722 1.36	0.682 1.16	0.833 1.35	1.374 1.98	1.162 1.71	0.506 0.65	2.774 5.99
Long-Term Debt > 0	−0.158 −2.17	−0.387 −4.70	−0.304 −4.89	−0.308 −4.71	−0.397 −4.67	−0.234 −2.27	−0.205 −2.37	−0.097 −1.55	−0.142 −2.51
$\ln(P_0)$	−0.317 −6.76	−0.288 −5.53	−0.263 −6.84	−0.304 −6.88	−0.326 −6.41	−0.363 −5.39	−0.430 −7.97	−0.417 −9.00	−0.094 −2.56
Dividend Yield	−8.774 −2.42	−2.569 −0.71	−0.845 −0.27	−0.590 −0.18	−1.602 −0.45	−11.385 −2.94	−14.061 −4.17	−8.866 −2.70	−6.430 −3.04
Heckman's Lambda	−2.044 −4.86	−1.887 −4.45	−2.040 −6.10	−2.306 −6.13	−2.403 −6.07	−1.598 −3.43	−0.491 −1.23	0.720 2.05	
KZ-Index	−0.207 −8.54					−0.156 −4.98	−0.156 −5.94	−0.068 −2.81	−0.037 −1.68
CF Shortfall		−0.675 −3.20				−0.423 −1.61	−0.368 −1.78	−0.192 −0.99	−0.593 −3.54
Interest Burden		−0.006 −0.32				−0.002 −0.11	−0.060 −2.40	−0.038 −5.92	−0.003 −0.61

04 Empirical Tests of the Model

- CPHIGH, that equals 1 if the county in which the firm is headquartered has an above-median gambling propensity
- stock option grants increase in the degree of probability weighting

TABLE 7

Option Grants and the Degree of Probability Weighting

Table 7 presents regressions of the number of employee stock options on firm volatility and proxies for the degree of probability weighting. The dependent variable in the LPMs in columns (3) and (4) is ESOPlan. The dependent variable in all other regressions is $\ln(1 + n_O)$. CPHIGH is an indicator variable that is high if the ratio of Catholics to Protestants in the county population where the firm is headquartered is above median in a given year. "Heckman's Lambda" is a self-selection variable from a 1st-stage probit model. All other variables have been previously defined in Table 3. Additional control variables are the control variables used in Table 6. Industry dummy variables are based on the 3-digit SIC code. Robust *t*-statistics with clustering at the firm level are given below the coefficient estimates.

Variable	OLS (1)	OLS (2)	LPM (3)	LPM (4)	OLS (5)	OLS (6)	OLS (7)	OLS (8)
Volatility	1.196	1.021	0.172	0.180	1.731	1.470	1.329	0.913
	6.82	3.64	3.97	2.58	12.53	7.14	7.17	3.23
Volatility × New Economy Firm	1.081	0.996						
	5.28	3.07						
New Economy Firm	−0.180	−0.045		0.162		1.028		1.001
	−1.19	−0.22		2.93		5.67		5.67
CPHIGH			0.048	0.040	0.223	0.156	−0.084	−0.215
			3.45	2.16	4.93	2.69	−0.91	−1.79
Volatility × CPHIGH							0.583	0.800
							3.51	3.01
ln(Sales)	−0.180	−0.163	−0.023	−0.007	−0.115	−0.094	−0.111	−0.087
	−8.35	−5.67	−4.56	−0.90	−5.83	−3.53	−5.64	−3.23
Tobin's Q	0.159	0.246	0.007	0.003	0.176	0.224	0.176	0.223
	11.77	9.82	1.99	0.40	14.44	9.42	14.64	9.49
R&D	2.250	3.271	0.415	0.907	1.224	1.776	1.056	1.535
	5.21	5.59	3.59	5.06	2.28	2.77	1.97	2.45
Long-Term Debt > 0	−0.127	−0.121	−0.016	−0.032	−0.329	−0.247	−0.321	−0.244
	−2.15	−1.39	−1.10	−1.32	−6.41	−3.12	−6.30	−3.13
$\ln(P_O)$	−0.160	−0.182			−0.251	−0.403	−0.256	−0.408
	−4.56	−3.25			−8.30	−8.34	−8.52	−8.61
Dividend Yield	3.993	3.875			−4.153	−11.526	−3.801	−10.902
	1.73	1.33			−1.74	−4.24	−1.59	−4.02
Heckman's Lambda	−1.168	−0.857			−1.165	−0.666	−1.259	−0.826
	−9.53	−6.07			−4.48	−2.05	−4.80	−2.50
Additional controls	No	Yes	No	Yes	No	Yes	No	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.580	0.541	0.269	0.259	0.718	0.735	0.719	0.737
N	8,510	4,296	14,612	7,936	8,510	4,296	8,510	4,296

05 Conclusion

- Firms with high stock return volatility grant more stock options to their nonexecutive employees.

- A calibrated model in which a risk-neutral firm bargains with employees with cumulative prospect theory preferences can explain the empirical findings remarkably well.

- Suggesting that risky firms can profitably use stock options to cater to an employee demand for long-shot bets, which adds a new dimension to the debate on the effectiveness of stock option compensation.

Drawbacks

- The lack of available experimental and psychological guidance on how individuals set reference points for complex distributions like payoffs from stock options is a clear obstacle for using prospect theory in applied work.

- My approach is in reduced form, and I do not solve for the optimal contract. Instead, I model contracts based on the structure observed in the data.

- My model implies potentially large savings in wage costs for firms with broad-based option plans. Good wage data for individual firms are not publicly available for most corporations, so this implication is hard to test.