To Reload or Not To Reload? Motivating Risk-Averse Executives Using Employee Stock Options With An Enhanced Reload Feature

Djekic Davor [1]

[1]Bocconi University

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Employee Stock Options

- ESOs are call options on firm's stock $\rightarrow \pi \uparrow$ when stock appreciates
- Features: strike price, maturity, vesting, OTM/ATM/ITM + non-transferability, limited hedging
- Why? Incentive alignment, talent attraction, deferred cash expenditure, ...
- Value = Intrinsic value + Time value

Literature Review I

- Sharp increase starting in 1990: ownership concentration, liquidity, CEO and institutional ownership, investment intensity, and historical market returns *(Pasternack et al., 2002)*
- Now, in US: 6,533 ESO plans, holding total assets \$2.1+ trillion *(NCEO, 2024)*; but preference towards other performance-based compensation *(Frydman and Jenter, 2010)*
- Separation corporate ownership and control (. . .) $\rightarrow$ Re-align incentives *(Jensen and Meckling, 1976)* + take higher risk *(Jensen and Murphy, 1990)*
- Undiversified managers at avg NYSE firm value ESOs 30% less than market value, while those at startups value theirs 47% less *(Meulbroek, 2001)* $\rightarrow$ Deadweight loss

Literature Review II

- Executives' risk aversion is lower than average, but still there are some differences - also related to age and gender (Brenner (2015); Carter, Franco, and Gine (2017); Iqbal, Sewon, and Baek (2006))
- *Cook, 1987* introduces reload options: at exercise, receive one stock and one new option
- *Huand et al. (2013)* introduce Dynamic ESOs: at exercise, receive part in stock and part in option
  - $\rightarrow$ Recoup time value
  - $+$ For executive: lock-in gain, decrease risk exposure, better compensation
  - $+$ For firm: higher risk-taking, tax benefits

The Problem

2 facts:

1. Risk aversion (+ non-transferability) drives the difference between executive valuation and market value of ESOs
2. Executives are exposed to undiversified (firm-specific) risk

→ **Idea: Can we re-align values and incentives by offering two different options, one of which offers a risk premium?**

- Give the *right* option to the *right* executive
- Who gets what?
- Who is better off in the equilibrium?

Theoretical Model

Main Elements

1. Stock Price
2. 2 Options: RN and $R_{\alpha,\gamma}$
3. Risk-averse executives with heterogeneous risk aversion
4. Public, risk-neutral firm
5. Problem with adverse selection and moral hazard

Theoretical Model

Stock Price

- Geometric Brownian motion process $W = \{W_t, \mathscr{F}_t\}_{t\geq 0}$ on a probability space $(\Omega, \mathscr{F}, P)$
- Stock price follows: $dS_t = \mu S_t dt + \bar{\sigma} S_t dW_t$
- When managed by the executive: $dS_t = \alpha a_t dt + \delta \sigma_t S_t dt + \bar{\sigma} S_t dW_t$
    - $a = \{a_t\}_{t\geq 0}$ is effort and $\sigma = \{\sigma_t\}_{t\geq 0}$ is volatility
    - $\delta \in [0,1]$: impact of project on firm's volatility
    - $\alpha \in [0,1]$: relevance of executive

Theoretical Model

2 Options: RN and $R_{\alpha,\gamma}$

- Fix $S_0, K, T, v \rightarrow RN + R_{\alpha,\gamma}$ for $\alpha, \gamma \in [0,1]$
- $R_{\alpha,\gamma}$: at exercise, (i) α in stock, (ii) $(1-\alpha+\gamma)$ in new RN
  - $\gamma > 0$: risk premium
  - $R_{1,0} = RN$
- Contract space is $\Theta = \left(\mathbb{1}_{RN}, \{\mathbb{1}_{R_{\alpha,\gamma}}\}_{\alpha\in(0,1),\gamma\in[0,1)}\right) \times \mathbb{Z}^+$
  - $\rightarrow \theta_{RN} = (\mathbb{1}_{RN}, n)$ and $\theta_R = (\mathbb{1}_{R_{\alpha,\gamma}}, n)$, with n fixed

Theoretical Model

2 Options: *RN* and $R_{\alpha,\gamma}$

Theoretical Model

Risk-averse executives

- $\rho \in \{\rho_L, \rho_H\}$ s.t. $\rho_L < \rho_H$
  - $\lambda = \mathbb{P}(\rho = \rho_L)$ is common knowledge
- $W_t = n_S S_t + n_O (S_t - K)^+ + c(1 + r_f)^t$
  - W_0 determines the composition of portfolio: $50 - 50$ or $67 - 33$
- $\bar{u}(W_t) = \frac{W_t^{1-\rho}}{1-\rho}$
- $u_\rho(W_t, a_t) = \frac{W_t^{1-\rho}}{1-\rho} - \frac{1}{2} a_t^2$
- $\rightarrow U_\rho(a, \sigma) = \mathbb{E}\left[r \int_0^T e^{-rt} u_\rho(W_t, a_t) dt \right]$
- **Chooses** $(a, \sigma, \theta) \in \{a_L, a_H\} \times \{\sigma_L, \sigma_H\} \times \{\theta_{RN}, \theta_{R_{\alpha,\gamma}}\}$

Theoretical Model

Public, risk-neutral firm

- $\Pi(\alpha, \gamma; \beta, \mu) = \beta\,\mathbb{E}\Big[S_T\Big] - \Big[\mu C(\theta_{RN}) + (1-\mu)C(\theta_{R_{\alpha,\gamma}})\Big]$
  - In principle, $\mu \neq \lambda$
- **Chooses** (α, γ) **for** $R_{\alpha,\gamma}$

Theoretical Model

Agent's Problem

$$
\begin{aligned}
\max_{a,\sigma,\theta} \quad & U_\rho(a,\sigma,\theta) \\
\text{s.t.} \quad & a \in \{a_L, a_H\} \\
& \sigma \in \{\sigma_L, \sigma_H\} \\
& \theta \in \{\theta_{RN}, \theta_{R_{\alpha,\gamma}}\} \\
& U_\rho(a,\sigma,\theta) \geq \hat{U}
\end{aligned}
$$

Theoretical Model

Firm's Problem(s)

$$
\begin{aligned}
\max_{\alpha,\gamma} \quad & \Pi(\alpha, \gamma; \beta, \mu) & \\
\text{s.t.} \quad & U_\rho(a^*, \sigma^*, \theta^*) \geq \hat{U} & \forall \rho \in \{\rho_L, \rho_H\} \\
& U_\rho(a^*, \sigma^*, \theta^*) \geq U_\rho(a, \sigma, \theta) & \forall \rho \in \{\rho_L, \rho_H\} \\
& & \forall a \in \{a_L, a_H\}, \\
& & \forall \sigma \in \{\sigma_L, \sigma_H\}, \\
& & \forall \theta \in \{\theta_{RN}, \theta_{R_{\alpha,\gamma}}\}
\end{aligned}
$$

Two Approaches

1

Qualitative Analysis

Valuation of Options

Analysis of incentives: Delta + Vega

2

Numerical Simulations

Parameter Choice

Simulations' results

1. Qualitative Analysis

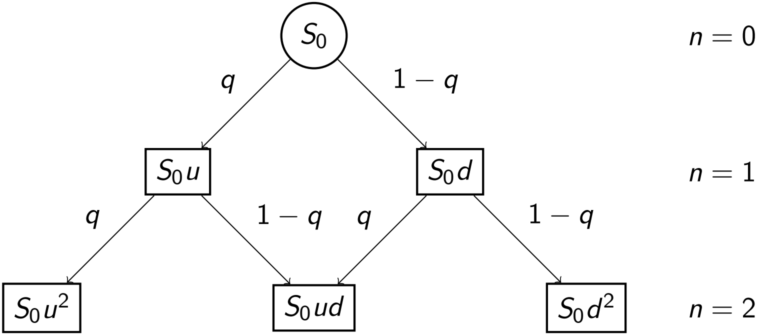
Valuation of Options

- For Firm: binomial (risk-neutral) pricing
  - C(RN) and C($R_{\alpha,\gamma}$) computed backwards, with early exercise multiple technique by *Hull and White (2004)*
  - $R_{\alpha,\gamma}$ valuation accounts for recouped time value
- For Executive: utility maximization
  - E_c such that $U_\rho(n_s, n_o, c) = U_\rho(n_S, 0, c + E_c)$

- $\rightarrow$ $R_{\alpha,\gamma}$ is always more expensive than RN, increasingly in α and γ
- $\rightarrow$ Executive value is always lower than firm value, but more stable for 50-50 agent
  - May be slightly estimated because utility-based method does not predict early exercise *Grasselli and Henderson (2009)*

1. Qualitative Analysis

Binomial tree with $n = 2$



1. Qualitative Analysis

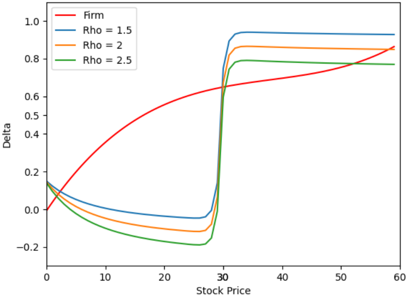
Incentives

- Delta and vega are sensitivities of the option price to stock price and volatility
    - **Objective:** predicted, by firm
    - **Subjective:** actual, by executive
- Computations are limited by computing power (6-8h to run one simulation)

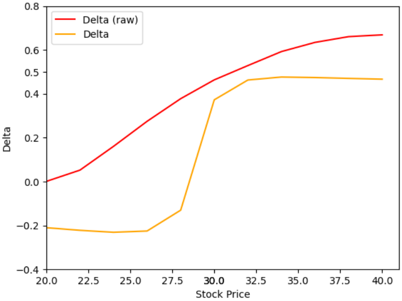
1. Qualitative Analysis

Effort Incentives

RN option



$R_{0.75,0.1}$ for $\rho = 2$ executive

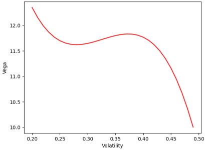


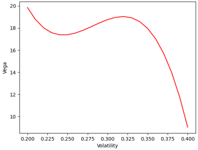
1. Qualitative Analysis

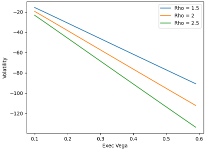
Volatility Incentives

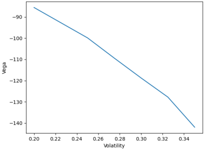
RN option

$R_{0.75,0.1}$ for $\rho = 2$ executive









1. Qualitative Analysis

Incentives

- Delta and vega are sensitivities of the option price to stock price and volatility
    - **Objective:** predicted, by firm
    - **Subjective:** actual, by executive
- Computations are limited by computing power (6-8h to run one simulation)
- $\rightarrow$ Objective incentive is always higher than subjective incentive, except for effort incentive with RN option slightly OTM/ITM
- $\rightarrow$ Incentives under the $R_{\alpha,\gamma}$ option are always lower than under the RN option

Numerical Simulations

- We run 100 paths, each with 5,000 points (one per trading day)
- Stock price simulations $\rightarrow$ Agent's controls $\rightarrow$ Firm's choice
- **Assume constant effort and volatility $\rightarrow$ NO instantaneous incentives**
- We set T=20 years; $\rho_L = 1.5$, $\rho_H = 2.5$ (Carpenter, 1998); $y_{R1} = 6$, $y_{RN} = y_{R2} = 7$ (Murphy and Vance (2019) for RN) $a_L = 0$, $a_H = 1$, $\sigma_L = 0$, $\sigma_H = 0.01$
- We allow for $\alpha \in A = \{0.2, 0.5, 0.6, 0.7, 0.75, 0.8, 0.9, 1\}$ and $\gamma \in \Gamma = \{0, 0.05, 0.1, 0.15, 0.2, 0.25, 0.5, 0.75, 1\}$
- Principal ranks all $(\alpha, \gamma, a^*_{\rho_L}, a^*_{\rho_H}, \sigma^*_{\rho_L}, \sigma^*_{\rho_H}, \theta^*_{\rho_L}, \theta^*_{\rho_H})$

Simulation Results

Numerical Simulations

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- → Results are robust to changes in main parameters: firm-side parameters — number of agents, lambda, beta — and agent-side parameters — rho, effort, sigma, years, delta, alpha
- → But not for $a_L > 0$ and when $y_{R1} > y_{RN}$
  - But, reload options encourage early exercise (Hemmer, Matsunaga, and Shevlin, 1998).
- → Special cases (RN only, stock only, effort or volatility only) are not meaningful

Discussion of Results

- Both approaches suffer from computational capacity
- Contrasting results on incentives
  - Qualitative analysis does **not** account for cost of effort
  - But, cost of volatility is accounted for (overestimated (?))
- $R_{\alpha,\gamma}$ is never chosen in equilibrium, which is (surprising and) robust
- But, in numerical simulations, firm's profit difference is never too high

Future Research

- Limitations: block exercise, employee cannot leave firm, no stopping time, no firm preference on volatility
- $\rightarrow$ Solve algebraically: requires complex stochastic machinery + no guarantee that closed-form solution exists
- $\rightarrow$ Different utility function for firm (and agent): allows to account for private firms
  - Of the 6,322 companies with an ESOP, 5,866 are private while only 456 are publicly traded *(NCEO, 2024)*

Take-home

- We proposed a new type of option ($R_{\alpha,\gamma}$) and developed a novel valuation methodology
- There is difference between objective and subjective valuations (Meoulbreok 200.., Ingersoll (2006b)) and incentives
  - But, subjective incentive is not always lower than the predicted objective incentives
  - $\rightarrow$ Grant options slightly OTM for highest incentive
- RN is always chosen in equilibrium
- Some (older) literature relies on strong assumptions on parameters, and small changes change significantly the results
- But firm's profit difference is never too high, which leaves some possibility for further research

Thank you!