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

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Employee Stock Options (ESOs)

- **ESOs are call options on firm's stock**
- Features: strike price, maturity, vesting, OTM/ATM/ITM + non-transferability, limited hedging
- Why? Incentive alignment, talent attraction, deferred cash expenditure, . . .

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- Features: strike price, maturity, vesting, OTM/ATM/ITM + non-transferability, limited hedging
- Why? Incentive alignment, talent attraction, deferred cash expenditure, ...
- **ESO 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 shifting also towards other performance-based compensation (Frydman and Jenter, 2010)
- Deadweight loss: **undiversified managers at avg NYSE firm value ESOs 30% less than market value, while those at startups value theirs 47% less (Meulbroek, 2001)**
- Executives' risk aversion is lower than average, with some heterogeneity — also related to age and gender (Brenner (2015), Carter, Franco, and Gine (2017), Iqbal, Sewon, and Baek (2006))

Literature Review II

- Cook (1987) introduces reload options: at exercise, receive one stock and one new option
- Huang et al. (2013) introduce **Dynamic ESOs: at exercise, receive part in stock and part in option** (e.g., 70% stock, 30% new ESO)
    - For executive: recoup time value, lock-in gain, decrease risk exposure, better compensation scheme
    - For firm: higher risk-taking, tax benefits

The Problem

2 facts:

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

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Research Question

Can we re-align values and incentives by offering an additional ESO, that at exercise reloads and offers a risk premium, to heterogeneous executives?

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: $dS_t = \mu S_t dt + \bar{\sigma} S_t dW_t$

Theoretical Model

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- Stock price follows: $dS_t = \mu S_t dt + \bar{\sigma} S_t dW_t$
- When managed by executive: $\boldsymbol{dS_t = \alpha a_t dt + \delta \sigma_t S_t dt + \bar{\sigma} S_t dW_t}$
    - $a = \{a_t\}_{t \geq 0}$ 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

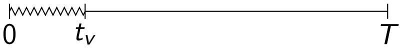
2 Options: RN and $R_{\alpha,\gamma}$

- Fix $S_0, K, T, v \to \boldsymbol{RN} + \boldsymbol{R_{\alpha,\gamma}}$ **for** $\boldsymbol{\alpha, \gamma \in [0, 1]}$
- $R_{\alpha,\gamma}$: at exercise, (i) α in stock, (ii) $(1 - \alpha + \gamma)$ in new RN
  - $\gamma > 0$: risk premium
  - $R_{1,0} = RN$

Theoretical Model

Example of $R_{0.75,0.1}$

Assume $K = 30$ and constant $S_t = 31$ for $t \in [0, 2T]$



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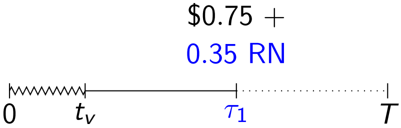

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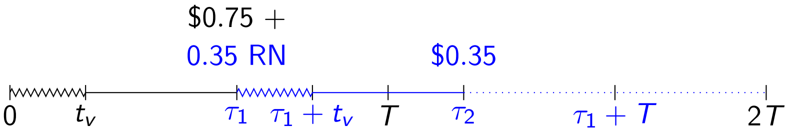
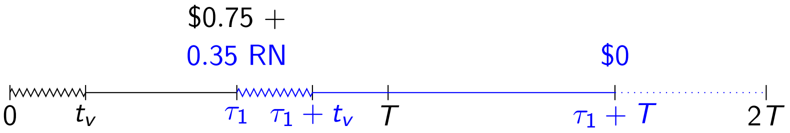


Theoretical Model

Example of $R_{0.75,0.1}$

Assume $K = 30$ and $S_t = 31$ for $t \in [0, \tau_1]$, $S_t = 29$ for $t \in [\tau_1, 2T]$



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: $67 - 33$ or $50 - 50$
- $u_\rho(W_t, a_t) = \frac{W_t^{1-\rho}}{1-\rho} - \frac{1}{2} a_t^2$
- $U_\rho(a, \sigma) = \mathbb{E}\left[r \int_0^T e^{-rt} u_\rho(W_t, a_t) dt \right]$

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- $U_\rho(a, \sigma) = \mathbb{E}\left[r \int_0^T e^{-rt} u_\rho(W_t, a_t) dt \right]$
- **Chooses** $(\boldsymbol{a}, \boldsymbol{\sigma}, \boldsymbol{\theta}) \in \{\boldsymbol{a_L}, \boldsymbol{a_H}\} \times \{\boldsymbol{\sigma_L}, \boldsymbol{\sigma_H}\} \times \{\boldsymbol{\theta_{RN}}, \boldsymbol{\theta_{R_{\alpha,\gamma}}}\}$

Theoretical Model

Public, risk-neutral firm

- $\Pi(\alpha, \gamma; \beta, \mu) = \beta\, \mathbb{E}\left[S_T\right] - \left[\mu C(\theta_{RN}) + (1-\mu) C(\theta_{R_{\alpha,\gamma}})\right]$
  - β: relevance of terminal stock price to firm
  - μ: fraction of executives choosing RN
  - In principle, $\mu \neq \lambda$

Theoretical Model

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- **Chooses (α, γ) for $R_{\alpha,\gamma}$**

Theoretical Model

Agent's Problem

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

Theoretical Model

Firm's Problem(s)

No moral hazard nor adverse selection:

$$\max_{\alpha,\gamma} \quad \Pi(\alpha,\gamma;\beta,\mu)$$
$$\text{s.t.} \quad U_\rho(a^*,\sigma^*,\theta^*) \geq \hat{U} \quad \forall \rho \in \{\rho_L,\rho_H\}$$

Theoretical Model

Firm's Problem(s)

With moral hazard:

$$
\begin{array}{lll}
\max\limits_{\alpha,\gamma} & \Pi(\alpha,\gamma;\beta,\mu) & \\
\text{s.t.} & U_\rho(a^*,\sigma^*,\theta^*) \geq \hat{U} & \forall\rho \in \{\rho_L,\rho_H\} \\
 & U_\rho(a^*,\sigma^*,\theta^*) \geq U_\rho(a,\sigma,\theta^*) & \forall\rho \in \{\rho_L,\rho_H\}, \\
 & & \forall a \in \{a_L,a_H\}, \\
 & & \forall\sigma \in \{\sigma_L,\sigma_H\}
\end{array}
$$

Theoretical Model

Firm's Problem(s)

With moral hazard and adverse selection:

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

Two Approaches

1

Qualitative Analysis

Firm and Exec valuations

Analysis of incentives

2

Numerical Simulations

Simulations' results

Robustness checks

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 $U_\rho(n_s, n_o, c) = U_\rho(n_S, 0, c + E_c)$

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- **$\Rightarrow$ $R_{\alpha,\gamma}$ is always more expensive than RN for the firm, decreasingly in α and increasingly in γ**

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

1. Qualitative Analysis

Incentives

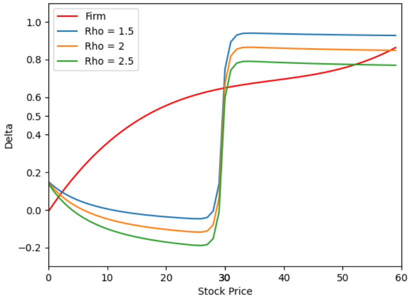
- Delta and vega are sensitivities of the option price to resp. stock price and volatility
  - **Objective:** predicted, by firm
  - **Subjective:** actual, by executive
- **Computations are limited by computing power** (6-8h to run one simulation)

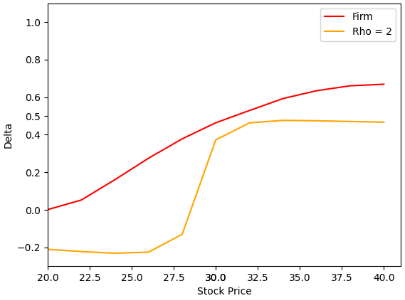
1. Qualitative Analysis

Effort Incentives (K = 30)

RN option

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

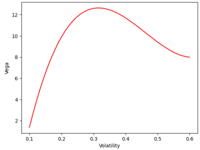
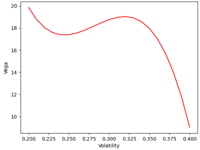
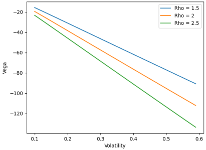
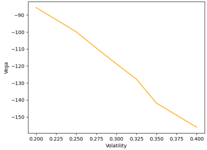




⇒ **Subjective > objective only when RN option slightly OTM/ITM**

1. Qualitative Analysis

Volatility Incentives

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

$\Rightarrow$ **Subjective is always negative, while objective is always positive**

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 $\gamma \in \Gamma = \{0, 0.05, 0.1, 0.15, 0.2, 0.25, 0.5, 0.75, 1\}$

Simulation Results

Best	α^*	γ^*	ρ_L				ρ_H				$\mathbb{E}[S_T]$	Π
			θ^*	a^*	σ^*	U	θ^*	a^*	σ^*	U		
1	A	Γ	RN	1	0.01	222.42	RN	1	0.01	24.73	222	209.39
2	A	Γ	RN	0	0.01	296.61	RN	0	0.01	98.91	30	17.71
3	0.75, 0.8, 0.9, 1	0	RN	0	0.01	296.61	RN	0	0.01	98.91	30	17.71
3	1	0.05	RN	0	0.01	296.61	RN	0	0.01	98.91	30	17.71

Numerical Simulations

- $\Rightarrow$ **Results are robust to changes in main parameters**
  - Except for $a_L > 0$ or $y_{R1} > y_{RN}$ (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 **limited computational capacity**

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Discussion of Results

- Both approaches suffer from **limited computational capacity**
- Contrasting results on incentives
  - Qualitative analysis does **not** account for cost of effort
  - But, cost of volatility is accounted for (maybe overestimated)
- $\boldsymbol{R_{\alpha,\gamma}}$ **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 of our analysis: block exercise, employee cannot leave firm, no stopping time, no firm preference on volatility

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- $\Rightarrow$ **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)

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- $\Rightarrow$ **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)
- Some (older) **literature relies on strong assumptions on parameters, and small changes change significantly the results**

Take-home

- We proposed a new type of option ($R_{\alpha,\gamma}$) for which we developed a novel valuation methodology

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- **RN is always chosen in equilibrium**
- There is **difference between objective and subjective valuations** (Meulbroek (2001), Ingersoll (2006)) **and incentives**
  - But, subjective incentive is not always lower than the predicted objective incentives
  - $\Rightarrow$ Grant/reset ESOs slightly ITM/OTM for highest incentive

Thank you!

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Valuation of RN option

```
if not vested:
    C[j] = disc * (q*C_up + (1-q)*C_down)
elif vested & (S>=K*m):
    C[j] = S - K
elif vested & (S<K*m):
    C[j] = disc * (q*C_up + (1-q)*C_down)
```

Valuation of $R_{\alpha,\gamma}$ option

```
if not vested:
    C[j] = disc * (q*C_up + (1-q)*C_down)
elif vested & (S >= K*m):
    C[j] =  (1+gamma)*(S - K) +
            (1-alpha+gamma)*(black_scholes(S,K,T,r,sigma)-(
               S-K))
elif vested & (S < K*m):
    C[j] = disc * (q*C_up + (1-q)*C_down)
```

Valuation of RN option in a utility maximization setting

```
cont_value = q_u * U[j+1,i+1] + q_d*U[j,i+1] + q_m*U[j,i]
excs_value = util(c*((1+r/N)**n)+ n_s*S[j,n] +
                n_o*max(0, S[j,n]-K), rho)

if vested:
    U[j,i] = max(cont_value, excs_value)
else:
    U[j,i] = cont_value
```

Valuation of $R_{\alpha,\gamma}$ option in a utility maximization setting

```
cont_value = q_u * U[j+1,i+1] + q_d*U[j,i+1] + q_m*U[j,i]
excs_value = util(  c*((1+r/N)**n) +
                    n_s*S[j,n] +
                    max(0,
                        n_o*(alpha*(S[j,n]-K)) +
                        CE_rn_trinomial(S[j,n],S[j,n],T,v,r
                            ,N,sigma,rho,n_s,n_o*(1-alpha+
                            gamma),c*((1+r/N)**n))), rho)

if vested:
    U[j,i] = max(cont_value, excs_value)
else:
    U[j,i] = cont_value
```

Firm Cost and Executive Value for different values of α

α	γ	Firm Cost	Executive Value			Firm Cost Ratio	Exec. Value Ratio			Ptf
			$\rho = 1.5$	$\rho = 2$	$\rho = 2.5$		$\rho = 1.5$	$\rho = 2$	$\rho = 2.5$	
1	0	12.44	5.567	2.303	-0.957	1	1	1	1	67-33
0.75	0	13.58	5.533	2.237	-1.046	1.092	0.994	0.971	1.093	67-33
0.5	0	14.72	5.418	2.141	-1.128	1.184	0.973	0.930	1.178	67-33
1	0	12.44	9.742	7.865	5.992	1	1	1	1	50-50
0.75	0	13.58	9.750	7.855	5.964	1.092	1.001	0.999	0.995	50-50
0.5	0	14.72	9.611	7.728	5.848	1.184	0.987	0.983	0.976	50-50