The Value of Being Lucky: Option Backdating and Non-diversifiable Risk

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Lucky?

- Bebchuk, Grinstein and Peyer (2010) “Lucky CEOs and lucky Directors”
- “Lucky” if executive receives option compensation with the “best terms” (granted on day with lowest stock price) over the month.
- In their data over 1996-2005, find 15% of grants to CEOs are “lucky”
Executive Stock Options: An Introduction

- 62% of S&P 500 CEOs received stock options in 2013
- American call options, commonly granted at-the-money with maturity of 10 years
- Options non-transferable and corporate insiders subject to trading constraints. Inability of executive to hedge means exposed to non-diversifiable risk whilst hold → Black Scholes model not appropriate
- Utility-based models well studied and able to explain early exercise
- Firms permitted to use a Modified Black Scholes with option expiry set to options’ expected life
Executive Stock Options: Valuation

- Carpenter et al (2010, 2013) demonstrate MBS approximation involves significant errors which vary with firm, option and option holder characteristics.
Executive Stock Options: Early Exercise

- Early exercise of option is well documented - Bettis, Bizjak and Lemmon (2005) find, on average, options exercised more than 4 years prior to expiry.
- Exposure to non-diversifiable risk → Early exercise.
What is Option Backdating?

- The practice of *retrospectively* choosing an stock option grant date when the stock price was lower than actual grant date, and disclosing falsely that at-the-money options were granted at that earlier date. Automatically in-the-money


- Pre-SOX in 2002, executives could report option grants to the SEC 45 days after end of fiscal year.

- At-the-money options received favourable accounting treatment
Option Backdating: An Example

- Suppose a board meeting is scheduled for 30 April and executive expects to be awarded at-the-money options.
- Say the stock price has risen during April and is $40 on 30 April. On 15 April the stock price was only $35.
- At meeting, executive(s) decide to declare received at-the-money options on 15 April, and file an SEC report to say 15 April is grant date
- Options are already $5 in-the-money on 30 April!
Empirical Evidence: Option Backdating

- Lie (2005) first identified V-shaped abnormal return patterns & suggested advantageous timing
- Heron and Lie (2009) estimate 13.6% of grants were backdated (1996-2005) & 29.2% of firms in sample at some point backdated grants
- Bebchuk, Grinstein and Peyer (2010) propose new test using price ranks - "lucky" if grant is at lowest price of month. Find 15% of grants to CEOs are "lucky".
What we do

Ex ante, executives who have opportunity to backdate should take this into account in their valuation. We provide ex ante estimates of benefits to executives (and shareholder costs) from opportunity to backdate grants taking account of:

- executive's trading restrictions and exposure to non-diversifiable risk
- early exercise

Value of opportunity to backdate involves lookback feature - anticipates choosing best grant date over a backdating window. Characterize lucky grants as at-the-money at lowest stock price of month (BGP (2010)).
Our motivation

To answer two questions:

- Why did backdating occur? Magnitude of (ex post) benefits of backdating in literature are modest.
- Why was backdating so prevalent in high tech firms and those with highly volatile stock prices?
Backdating: A Model 1

- Executives anticipate receiving \( N \) at-the-money call options at end-of-month \( T_0 \). Options are American style with life of \( T \) years.
- If no opportunity to backdate, the benchmark is the time 0 value \( V_{nb} \) of \( N \) at-the-money American call options granted at end-of-month \( T_0 \).
- If opportunity to backdate, choose best strike \( J = \min_{0 \leq u \leq T_0} S_u \) on date \( t_{min} \in [0, T_0] \) in one month window.
- Calculate time 0 value, \( V_b \) of \( N \) strike \( J \) American call options granted at \( t_{min} \).
- Report ex post that received at-the-money strike \( J \) options at \( t_{min} \). In fact, in-the-money at month end, \( T_0 \).
Backdating: A Model II

Executive cannot trade the underlying stock $S$. Investment opportunities consist of a bond with constant riskless rate $r$ and market portfolio, $M_t$.

\[
\frac{dS_t}{S_t} = (\nu - q)dt + \eta dB_t; \quad \nu = r + \beta(\mu - r); \quad (1)
\]

\[
\frac{dM_t}{M_t} = \mu dt + \sigma dZ_t \quad (2)
\]

with standard Brownian motions $B$ and $Z$ with $\rho \in (-1, 1)$. Define $\beta = \rho \eta / \sigma$. 
Backdating: A Model III

Executive’s trading or outside wealth $W_u; u \geq t$ follows

$$dW_u = (rW_u + \theta_u(\mu - r))du + \theta_u \sigma dZ_u; \ W_t = w$$ (3)

given initial wealth $w$, cash amount $\theta_s$ in $M$ at time $s$

Objective: max expected utility of wealth at option maturity $T_0 + T$ over choice of exercise time $\tau$ and $\theta_u$

Assume CARA, $U(x) = -e^{-\gamma x}; \ \gamma > 0$
Valuation during \([T_0, T_0 + T]\)

After \(T_0\), \(N\) American calls with known strike \(J = \min_{0 \leq u \leq T_0} S_u\). The value to the executive \(\mathcal{V}_b(u, W_u, S_u; J)\) of \(N\) exercisable calls with strike \(J\), wealth \(W_u\), optimal choice over \(\theta_u\) and exercise, solves:

\[
\mathcal{V}_b(u, W_u, S_u; J) \geq \mathcal{M}(u, W_u + N(S_u - J)^+, T_0 + T) \tag{4}
\]

\[
\frac{\partial \mathcal{V}_b}{\partial t} + \sup_{\theta} \{ \mathcal{L} \mathcal{V}_b \} \leq 0 \tag{5}
\]

where \(\mathcal{L}\) is defined by

\[
\mathcal{L} = \frac{\eta^2 s^2}{2} \frac{\partial^2}{\partial s^2} + (\nu - q) s \frac{\partial}{\partial s} + \rho \theta \sigma \eta s \frac{\partial^2}{\partial w \partial s} + \frac{\theta^2 \sigma^2}{2} \frac{\partial^2}{\partial w^2} + [\theta(\mu - r) + rw] \frac{\partial}{\partial w}
\]
Exercise value $\mathcal{M}(u, W_u + N(S_u - J)^+, T_0 + T)$ is the value derived from optimally investing the exercise proceeds and any cash wealth until $T_0 + T$, given by (Merton (1971)):

$$\mathcal{M}(t, w, \bar{T}) = \sup_{\{\theta_s\}_{t \leq s \leq \bar{T}}} \mathbb{E}U(W_{\bar{T}} | W_t = w) = -e^{-\gamma w e^{r(\bar{T}-t)}} e^{-\frac{(\mu-r)^2}{2\sigma^2} (\bar{T}-t)}.$$  \hspace{1cm} (6)

Optimal exercise time $\tau$ is characterized by:

$$\tau = \inf\{ T_0 \leq u \leq T_0 + T : \mathcal{Y}_b(u, W_u, S_u; J) = \mathcal{M}(u, W_u + N(S_u - J)^+, T_0 + T) \}. $$

Scale out dependence on wealth and re-express

$$\tau = \inf\{ T_0 \leq u \leq T_0 + T : S_u = S_b^*(u) \}. $$
Define UI value of the backdated grant, \( V_b(u, S_u; J) \); \( u \in [T_0, T_0 + T] \) via:

\[
\mathcal{Y}_b(u, W_u, S_u; J) = \mathcal{M}(u, W_u + V_b(u, S_u; J), T_0 + T).
\]

Solve free boundary problem, with boundary conditions:

\[
\mathcal{Y}_b(T_0 + T, W_{T_0 + T}, S_{T_0 + T}; J) = \mathcal{M}(T_0 + T, W_{T_0} + N(S_{T_0} - J)^+, T_0 + T)
\]

and

\[
\mathcal{Y}_b(u, W_u, 0; J) = \mathcal{M}(u, W_u, T_0 + T)
\]

numerically using finite difference methods.

Although the strike \( J = \min_{0 \leq u \leq T_0} S_u \) is known during \([T_0, T_0 + T]\), we will need the values at \( T_0 \) for each possible value of \( J \), and hence we need a 3-d grid \((t, S, J)\).
Valuation during backdating window $[0, T_0]$

Over $[0, T_0]$, grant cannot be exercised.

A floating strike lookback call option with maturity $T_0$ allows holder to buy stock at best price - payoff is $S_{T_0} - J$.

Use conditioning to reduce the valuation to that of a European derivative with payoff at $T_0$ of $V_b(T_0, S_{T_0}; J)$. Payoff non-linear in $J$.

Then

$$V_b(u, W_u, S_u; J) = \sup_{\{\theta_u\}_{0 \leq u \leq T_0}} EM(T_0, W_{T_0} + V_b(T_0, S_{T_0}; J), T_0 + T); 0 \leq u \leq T_0$$

For $u \in [0, T_0]$, $V_b$ solves pde in (4) and (5) with a boundary condition at $T_0$. Solve via finite differences with: upper bound for large $S$, lower bound for $S = J$ and implicit boundary condition for $J = 0$. 
Valuing grant without backdating: A benchmark

Today, the executive has \( N \) forward-starting at-the-money American calls with unknown stochastic strike \( S_{T_0} \).

After \( T_0 \), use same framework with strike \( S_{T_0} \), giving option value \( V_{nb}(u, S_u, S_{T_0}) \).

For \( u \leq T_0 \), we use conditioning to reduce the valuation to that of a European derivative with payoff at \( T_0 \) of \( V_{nb}(T_0, S_{T_0}, S_{T_0}) \).

\[
\mathcal{V}_{nb}(u, W_u, S_u, S_{T_0}) = \sup_{\theta_u; 0 \leq u \leq T_0} \mathbb{E}M(T_0, W_{T_0} + V_{nb}(T_0, S_{T_0}, S_{T_0}), T_0 + T)
\]

Use pde transformation techniques to give:

\[
V_{nb}(u, S_u, S_{T_0}) = -\frac{1}{\gamma(1 - \rho^2)e^{r(T_0 + T - u)}} \log \mathbb{E}[e^{-\gamma(1 - \rho^2)V_{nb}(T_0, S_{T_0}, S_{T_0})e^{r(T_0 + T - T_0)}]}.
\]
Estimates of Magnitude of Benefit of Backdating

- Empirical literature has provided ex post estimates of the gains to executives from backdating - and found these are modest.
- All calculated using Modified Black Scholes model. Fixed adjustment to maturity. Estimate increase in grant value for a % reduction in strike.
- Narayanan, Schipani and Seyhun (2007) obtain on average 1.25%-3.66% of option value.
- Narayanan and Seyhun (2008) demonstrate-example an 8% “windfall” by comparing an at-the-money grant with the grant value if the strike price was backdated by 30 days to 88% of the prevailing stock price.
Significant ex ante benefit from backdating opportunity

- Consider $N = 1m$ options, base level of risk aversion $\gamma = 0.2$ and base parameters $r = 0.05, q = 0, \eta = 0.6, S_0 = 10$.

- Value in absence of backdating $V_{nb}$ is $2.12m$. Backdating over a one month window increases value $V_b$ to $2.48m$, or 16.9%.

- For base risk aversion, percentage gains given one month window range between 7.2% and 20.3%.

- Under Black Scholes, value in absence of backdating $V_{nb}^{BS}$ is $7.4m$. Backdating over one month increases this to $V_b^{BS} = 7.63m$, or by 3.2%.

- Black Scholes percentage gains are much lower, and vary between 3.2 and 8.2%.
Although risk aversion and non-diversifiable risk reduce values of both backdated and non-backdated options relative to BS, there is a larger reduction for the at-the-money, non-backdated options.

Why? Option time-value is maximized close to at-the-money and far in-the-money options have little time value. Risk aversion impacts on time value as it only affects values whilst the executive continues to hold option.
Stock Volatility and Backdating: The Evidence

- Disproportionate number of high-tech firms implicated in backdating
- Heron and Lie (2009) find tech firms and firms with high stock price volatility are significantly more likely to manipulate grants (20.1% of non-high tech vs 32% of high-tech firms, 13.6% of firms with low vol vs 29% of firms with high vol)
- BGP (2010) show grant events were more likely to be lucky in months when difference between lowest and median stock price was greatest
Explaining volatility and backdating I

One line of reasoning given is that firms are "more likely to be able to take advantage of backdating options when the stock price is more variable" (Bizjak, Lemmon and Whitby (2009)).

...but intuition incomplete. By Black Scholes arguments, ATM calls more sensitive to volatility than ITM calls. Volatility has larger effect on value of non-backdated option.


Our American BS calculations take into account optimal exercise. However, still show that benefit of backdating drops as volatility increases.
Explaining volatility and backdating II

- We include non-diversifiable risk which resolves "puzzle"
- An ITM American call is still less sensitive to volatility than an ATM American call but the difference between their sensitivities is much *smaller* than under BS.
- Which effect dominates? Benefit from backdating, \( V_b / V_{nb} \) increases with volatility, as the expected strike discount is the dominant effect.
- Why? Risk aversion & non-diversifiable risk decreases option values & option vegas relative to BS. Option vegas can be negative for sufficiently far ITM options. American exercise places a lower bound on negative vega
The Value of Being Lucky: Option Backdating and Non-diversifiable Risk
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Table: Black Scholes values/costs of the option grant with and without the opportunity to backdate over a one month window. The option grant is \( N = 1 \) million American calls with a ten year maturity \( T = 10 \) and so all values and costs are expressed in millions of dollars. We take \( T_0 = 1/12 \) and \( S = 10 \). Top panel takes \( q = 0 \), lower panel takes \( q = 0.05 \). Both panels take \( r = 0.05 \).
Summary

- Ex ante, executives who have opportunity to backdate should take this into account in their valuation
- Value of opportunity to backdate involves lookback feature
- We quantify the value of the opportunity to backdate to executives in a model taking account of exposure to non-diversifiable risk and early/American exercise
- We demonstrate that the potential benefits/gains to a risk averse executive of a one month backdating opportunity are significant & vary between 7.2% and 20.3%
- Our model can explain the empirical finding that backdating was more prevalent among high tech/high volatility firms