Rescission and Repricing of Executive Stock Options:

Repricing Alternatives, Optimal Repricing Policy, and Early Exercise

by

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ABSTRACT

This dissertation consists of two chapters. Chapter 1 examines the ex-ante optimality of repricing and rescission of executive stock options while considering dilution effects and the tax effects of new accounting rules associated with repricing and rescission. Traditional repricing lowers the exercise price of outstanding options to match the declined market value of the stock. Rescission allows employees to cancel already-exercised options when share prices fall, which was not an issue until 2000 when the stock market plummeted. To my best knowledge, this study is the first research on examining the possible optimality of traditional repricing and rescission while considering the economic impact of changing accounting rules in an ex-ante contracting setting.

Chapter 2 examines the ex-ante optimality of repricing alternatives and derives an optimal repricing-triggered policy, which specify how deeply the options are under water before repricing takes place. In practice, traditional repricing practices have become obsolete since new accounting rules took effect in July 2000. To avoid associated variable accounting charges that cause uncertainty in future reported earnings, companies have tried several repricing alternatives as solutions to rescuing underwater options. This study not only justifies the occurrence of some repricing alternatives but also quantifies the impact of the marking-to-market feature imbedded in the new accounting rules.

Chapter 1:

Rescission and Repricing of Executive Stock Options

Abstract

We examine the ex-ante optimality of repricing and rescission of executive stock options while considering the tax effects of new accounting rules associated with repricing and rescission. Although there has been a body of empirical literature on repricing, the possible optimality of traditional repricing after considering the economic impact of changing accounting rules has not been addressed in an ex-ante contracting setting. Meanwhile, there has been little research conducted on rescission, which was not an issue until 2000 when the stock market plummeted. The theoretical predictions of our paper shed some light on these controversial practices.

Executive Summary

We examine the ex-ante optimality of repricing and rescission of executive stock options while considering dilution effects and the tax effects of new accounting rules associated with repricing and rescission. Repricing lowers the exercise price of outstanding options to match the declined market value of the stock and rescission allows employees to cancel already-exercised options when share prices fall. Although there has been a body of literature on repricing by using pre-1998 data, the possible optimality of traditional repricing after considering the economic impact of changing accounting rules has not been addressed in an ex-ante contracting setting. Our paper serves that purpose. Meanwhile, we note that there has been little empirical or analytical research conducted on rescission, which was not an issue until 2000 when the stock market plummeted. The theoretical predictions of our paper shed some light on these controversial practices.

We show that repricing loses its ex-ante dominance over the do-nothing strategy, as claimed by Acharya, John, and Sundaram (2000), after we incorporate dilution effects and the tax effects of new accounting rules associated with repricing. Taking effect in July 2000 and retroactive to December 15, 1998, those accounting rules forced companies to take a variable charge to earnings for repriced options. The variable charges, as opposed to one-time fixed costs, require companies to mark-to-market all repriced options in each quarterly earnings report. As a result, repricing is about equal to do-nothing in terms of the principal's (or shareholders') expected initial payoffs. On the other hand, the principal will be almost always better off in terms of expected initial payoffs under rescission than under the do-nothing policy if he/she takes the tax benefit and cash flows resulting from the option exercises into account and designs the initial option contract accordingly. Hence, given the new accounting rulings, rescission can still be an important and value-enhancing strategy from an ex-ante standpoint in our two-period model. Overall, the combined impact of dilution effects and tax effects on ex-ante contracting decision is economically significant.

1. Introduction

From an ex-ante contacting viewpoint, we answer the following research questions: (1) To reprice (rescind) or not to reprice (rescind)? (2) Can we justify the occurrence of repricing or rescission? and (3) Do the new accounting (variable) charges that took effect in July 2000 matter? Can the accounting effects alone explain the trend (starting from 2000) of using all sorts of alternatives[1] to direct repricing, instead of repricing underwater options directly? Put differently, the principal (or shareholders) selects an initial option-based incentive contract to maximize his/her expected initial payoff in a situation where repricing and/or rescission of the agent's (or the manager's) stock options are possible.

We extend the model of Acharya, John, and Sundaram (2000) (AJS, hereafter) to examine the ex-ante optimality of repricing and rescission of executive stock options (ESOs) while considering dilution effects and the tax effects of new accounting rules associated with repricing and rescission. Repricing options is a process of canceling existing outstanding options and reissuing new options at a lower strike price. Traditional repricings simply lower the exercise prices of existing options. Controversy arises from that practice in that repricing seemingly distorts the purpose of incentive alignment of ESOs by eliminating executives' downside risk while shareholders' downside risk remains. Rescission, another controversial practice, allows employees to cancel already-exercised options when share prices fell. Essentially, this practice allows companies to buy back the shares resulting from previous option exercises at original strike prices which are higher than current market values. This tax-motivated strategy is designed to rescue employees who, because of subsequent stock price declines, would not realize sufficient proceeds from selling stock after exercising options to pay the resulting taxes.

AJS study the ex-ante optimality of repricing ESOs without considering dilution effects and the tax effects of new accounting rules. We not only incorporate those effects in our two-period model but also analyze their influence on the agent's action in determining the likelihood of firm value in the subsequent period, and on the probability of underwater options being repriced. The new accounting rules associated with repricing and rescission took effect in July 2000 and were retroactive to December 15, 1998. As a result, we employ, for both principal and agent, terminal payoff structures different from those in AJS. More importantly, the recent changes in accounting rules may make traditional repricing obsolete. With all those rule changes in mind, companies have tried many repricing alternatives to avoid associated variable accounting costs.[2] The results of our paper lay foundation for evaluating repricing alternatives. Finally, the strategy of rescission was not considered in AJS.

[1] For instance, repricing alternatives include "delayed repricing", "advanced repricing", and "share swap". See Yang and Carleton (2002) for details.

[2] See Yang and Carleton (2002) for detailed description of repricing alternatives.

In addition to answering the research questions mentioned at the beginning of this section, our paper also provides analytical answers to the following empirical questions: (1) What is the estimated agency cost if the agent is compensated with stock options only? (2) Do executive stock options encourage risk-taking actions? (3) Is repricing still an optimal solution to underwater options as claimed by AJS once we consider the economic costs of accounting charges associated with repricing? (4) Can we justify the occurrence of rescission? (5) Is this a "Heads, I Win; Tails, You Lose" Game? Section 6 elucidates the questions mentioned above and discusses our findings.

Over the past decade, ESOs became a popular vehicle for corporations to attract, retain, and motivate key talent.[3] Top 200 US companies allocated a record 15.2% of their shares to employee stock options as a percent of shares outstanding in 2000, compared to 7.5% in 1990. Executive equity holdings account for nearly 70% of CEO compensation and most of the shares result from the exercise of their stock options.[4] The trend of maintaining stock-based incentives may continue, while the dilemmas of preserving shareholder interests and avoiding excess dilution remain.

Given an exuberant stock market in most of the 1990's, ESOs benefited each party involved. For employees, the goal is to profit from the in-the-money options, which is likely to occur when stock prices are high. For companies, not only do they pay smaller

[3] Among others, Hall and Murphy (2001) compare the usage of executive stock options for S&P 500 companies in 1999 to that in 1992.
[4] According to Pearl Meyer & Partners, an executive compensation consulting firm.

salaries and cash bonuses, but they also get a tax deduction on nonqualified stock options (NQSOs) when employees exercise their options. According to TIAA-CREF, 162 large companies that reported option-related tax deductions in 1999 reported a total of $15.3 billion in option-related tax savings.[5] As a result, however, the inflated earnings resulting from the tax benefits mentioned above should not be expected as the market 'turns south'. As for shareholders, while their earnings per share were diluted, they may have profited from high stock prices because of improved performance by highly motivated employees.

ESOs, however, are undergoing scrutiny in a period of fallen share prices and the pressure on the market for proven executives. The key task facing corporations is to devise innovative approaches to retaining as well as attracting key talent, in order to achieve the ultimate goal of creating real shareholder value in a fair manner. On one hand, to boost executives' morale, employers try to salvage underwater options while avoiding a variable charge to earnings under the new accounting rules.[6] On the other hand, shareholders have legitimate concerns about potential dilution and question why they even reward executives' poor performance by repricing underwater options and at shareholders' expense. Meanwhile, regulatory agencies such as the Securities and Exchange Commission (SEC) and the Financial Accounting Standards Board (FASB) will continue to be pressed by investor groups to require clearer and more uniform proxy

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[5] Cited in "Options Overdose", June 4, 2001, Wall Street Journal, page C1.

[6] Taking effect in July 2000, the accounting rules imposed by the Financial Accounting Standards Board (FASB) force companies to take a variable charge to earnings for repriced options. This means companies must mark-to-market all repriced options in each quarterly earnings report. See details in Section 2.1.

disclosure of equity compensation arrangements. The main focus of this paper is to assess the ex-ante optimality of rescuing strategies, such as repricing and rescission, in protecting shareholders' interests while facing the challenge of invigorating executive morale deflated as a result of plunging stock prices.

In 1999, Institutional Shareholder Services (ISS), which advises institutional investors on proxy issues and provides corporate governance services, recommended "no" votes on 55% of the stock plan proposals reviewed. Concern about the potential for high dilution was cited in almost 50% of the cases.[7] During the 2000 proxy season, ISS had a number of proposals targeting CEO compensation packages and ending option repricing along with shareholder approval of changes of existing incentive plans. Our paper will address or justify the concern for dilution in a dynamic setting and from an ex-ante contracting viewpoint.

There has been little empirical or analytical research conducted on rescission, which was not an issue until 2000 when the stock market plummeted. Soon after SEC issued the final Staff Announcement No. D-93 in February 2001[8], rescission almost disappeared in 2001[9] as quickly as it started in 2000. It is not known just how common the rescission

[7] Report of Trend 2000 by Pearl Meyer & Partners.

[8] The SEC Staff Announcement Topic No. D-93, "Accounting for the Rescission of the Exercise of Employee Stock Options" was issued in February 2001. This accounting guidance for rescission specifies the disclosures the SEC staff expects for these transactions and requires that variable accounting be followed for any 2001 rescission.

[9] The Investor Responsibility Research Center (IRRC), a source of independent research on corporate governance, proxy voting and corporate responsibility issues, reports that all option exercise rescissions

practice was in 2000, but it has generated considerable controversy about the use of ESOs. Neither is it clear whether rescission will recur when the next "bubble economy" (like the one at the end of 1990's) happens. The theoretical predictions of our paper shed some light on this controversial practice by showing that given the new accounting rulings, rescission can still be an important and value-enhancing strategy from an ex-ante standpoint.

We analyze the ex-ante optimal option-based incentive contract offered by shareholders (the 'principal', collectively) and the best response from executives (the 'agent') after taking into account the probability of repricing or rescission of the agent's options. We assume that both the principal and the agent know this probability distribution. We further assume the probability of existing options being repriced is exogenously given,[10] for example, as a function of the degree to which existing options are underwater.[11] We also acknowledge that the only economic impact of new accounting rulings associated with repricing and rescission is through the cash flows resulting from taxation. In other words, new accounting charges *per se* have no impact on the firm's terminal value until taxes are imposed as a result of asset liquidation at the terminal date. We assume all payoffs are received at the terminal date $t = 2$ in our two-

occurred in 2000. Among the rescissions that took place in 2000, there were only four cases disclosed in the 2001 proxy statements issued by companies in IRRC's research universe of approximately 4,000 companies.

[10] The probability of repricing when existing options are under water can be associated with firm characteristics, stock market conditions, and appropriate measures of board independence.

[11] Brenner, Sundaram and Yermack (2000) report that repricing results in a 40% drop, on average, in the strike price.

period model. The dilution effect of option exercises is also examined. Note that the agent's action can influence the likelihood of firm value being higher in the subsequent period. Subsections 1.1 and 1.2 give an introduction to the controversial practices: repricing and rescission, respectively.

1.1 Repricing

Repricing was the most common solution to underwater options until July 2000.[12] Taking effect in summer 2000 and retroactive to December 15, 1998, the accounting rules imposed by the FASB forced companies to take a variable charge to earnings for repriced options. These variable charges, as opposed to one-time fixed costs, require companies to mark-to-market all repriced options in each quarterly earnings report. As a result, traditional repricing may no longer be a solution for earning-sensitive companies in rescuing underwater options to retain key talent, while keeping shareholders satisfied.[13]

Repricing underwater options typically occurs in two ways. The company either lowers the exercise price of outstanding options to match the declined market value of the stock or cancels the old options and issues replacement options with a lower strike price. In either case, shareholder approval is necessarily required. Hence, the board of

[12] For example, other solutions include: (1) New grant: Hand out more options at a lower exercise price. (2) New shares: Certain amounts of restricted stocks are granted while leaving underwater options outstanding and (3) Share Swap: Restricted stock of like value is granted in exchange for the submission of underwater options.

directors, presumably acting in the interests of shareholders, exercises business judgment in agreeing to reprice underwater options to help the firm retain key employees without a cash outlay. The shareholders' concern is that, since executives usually own most of the options, the firm may "reward" poor executive performance at shareholders' expense. Are shareholders really worse off as executives are made better off? AJS find that repricing before the new accounting rulings mentioned above can still be a value-enhancing strategy, even from an ex-ante viewpoint. Does this finding still hold after taking into account the economic impact of the new accounting reporting method?

Under a recent accounting interpretation, companies must mark-to-market all repriced options in each quarterly earnings report. We assume that the tax consequences on reported earnings are the only economic cost associated with the new accounting rulings. Note that reported earnings will decrease as the intrinsic value of repriced options increases, whereas a subsequent decrease in intrinsic value will increase reported earnings. This impact on a company's income statement will continue until the option is exercised, forfeited, or expires unexercised.

In addition to the marking-to-market effect (or variable effect) mentioned above, companies will have to deduct the difference in value (or fixed effect) between the original stock options and the repriced options from its earnings when the repricing

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[13]According to IRRC, the Investor Responsibility Research Center, reported incidences of traditional repricing decrease from 167 in 1999 to 59 in 2000 as a result of the accounting rule changes.

occurs. This requires complex calculations of an option's intrinsic value at various stages before and after the repricing. Our paper examines the economic impact (through taxation) of these accounting charges on the optimality of rescuing strategies such as repricing and rescission.

1.2 Rescission

Rescission is another controversial practice, which allows employees to cancel already-exercised options after share prices fall. This tax-motivated strategy is designed to rescue employees who, because of subsequent stock price declines, would not have sufficient proceeds from selling stock after exercising options to pay the resulting taxes. In rescission, previous option exercises that resulted in purchases of stock whose price has plummeted are canceled and replacement options issued within the same tax year. Loosely speaking, the rescission treats the previous exercise as if it had never occurred for income tax purposes, so as to eliminate employee tax liabilities incurred from unrealized capital gains earlier in the year when stock prices were high.

The rest of this paper is organized as follows. Section 2 describes the literature review and related accounting rules. In Section 3, we introduce the model of AJS. Their benchmark strategy, pre-commitment (or do-nothing in our paper) is also discussed in Section 3. In Section 4, the dynamic optimality of repricing and rescission is evaluated separately while considering the new accounting rulings and the dilution effect. Section

5 summarizes the results and provides static comparisons given a certain set of state variables. Section 6 discusses estimated agency costs if the agent is compensated only with stock options and answers the questions mentioned in Section 2. Section 7 concludes.

2. Literature Review and Accounting Rules

Repricing has been studied empirically since the early 1990s. However, to the best of our knowledge, there is no study on repricing using post-1998 data to reflect the accounting rules changes since December 1998. For example, Gilson and Vetsuypens (1993) study repricings by financially distressed firms during 1981-87. Saly (1994) examines repricings following the stock market crash of 1987. Chance, Kumar, and Todd (1997) and Brenner, Sundaram, and Yermack (2000) use repricing data up to 1998 to characterize the repricing incidence by firm-specific factors and market conditions. They find that repricing is more likely to occur in firms with insider-dominated boards.

Chance, Kumar, and Todd (1997) examine the incidence of "direct repricing" -- corporations lowering the exercise prices of existing stock options. They find that option repricings follow periods of poor firm-specific performance, but not during market- or industry-wide declines. They also find the magnitude of the reduction in the exercise price is positively related to the firm's stock price performance and negatively related to the market's performance. More interestingly, Chance, Kumar, and Todd (1997) find no evidence to support the argument that lowering the exercise price leads to an increase in future stock prices. This means that repricing underwater options can be counterproductive and send the wrong signal to employees and shareholders. However, failure to rescue out-of-money stock options may cost the company more by demoralizing the workforce and reducing the firm's ability to retain and attract managerial talent in a competitive labor market. In our model, we parameterize the influence of the manager's action in determining the likelihood of final rewards, and, consequently, firm value.

The paper most related to ours is Acharya, John, and Sundaram (2000). AJS study the dynamic optimality of repricing executive stock options and characterize the conditions that affect the relative optimality of repricing. They find repricing can still be a value-enhancing strategy, even from an ex-ante viewpoint. In *some* cases, a repricing strategy almost always dominates the strategy of *pre-commitment*, which rules out repricing. Unlike AJS, our paper emphasizes the impacts of different factors (e.g.., the influence of the agent's action in determining the likelihood of firm value in the subsequent period, and the probability of underwater options being repriced) on the optimality of repricing while considering the economic impacts (through tax effects) of the new accounting rulings associated with repricing and rescission. Given the new accounting rules, we investigate if traditional repricing is still a value-enhancing strategy from an ex-ante viewpoint when the stock market plummets.

Section 2.1 and 2.2 present the recent changes of accounting rules, which are related to repricing and rescission, respectively.

2.1 Repricing

Repricing occurs when a company reduces the exercise price of a stock option whose current exercise price is above the market value of the underlying shares. This has become a sensitive subject since the beginning of 2001, for the following reasons. First, the Financial Accounting Standards Board's (FASB's) final interpretation No 44 of APB Opinion 25 discourages stock option repricings by forcing companies that reset the strike prices of options to take a charge to earnings.[14] Prior to 1999, favorable accounting treatment for stock options was available for repriced options, meaning that appreciation in the value of the underlying shares did not give rise to an accounting charge. FASB has eliminated this favorable accounting treatment for repricings that occur after December 15, 1998.[15] But the accounting penalty only applies if a company issues lower-priced replacement stock options within six months after the initial options are canceled. In

[14] On March 31, 2000, the FASB's final interpretation No 44 of APB Opinion 25 indicated that if companies wish to expedite the vesting of outstanding options or extend their exercise period after employee termination will need to take action prior to July 1, 2000 to avoid a charge to earnings. In addition, modifications to add automatic reload features to outstanding options should have been made prior to January 12, 2000, after which new accounting charges to earnings will be imposed under final APB Opinion 25.

[15] FASB's new Interpretation #44 narrows the circumstances under which companies may account for stock awards under the intrinsic value method governed by APB Opinion No. 25 (APB 25), which generally provides for the non-recognition of expense for grants of stock options having fixed terms. Whenever APB 25 accounting is not allowed, FASB Statement 123 requires expense recognition for the fair market value of the option on the date of the grant, spread over the vesting period.

other words, the variable accounting charge can be avoided if the cancellation and new grant are more than six months apart.

Second, there has been a movement, led in part by the former SEC chairman Arthur Levitt, to force companies to seek shareholder approval for employee stock option plans.[16] "It is shareholders' money that officers and directors are using to pay themselves," Levitt said during an address in December 2000 to an audience at the New York Federal Reserve. "Shareholders should not be diluted in the dark. I urge you not to miss the opportunity to comment."

Finally, option repricings seemingly reward employees for a company's falling stock price. Hence, the challenge facing firms is to devise innovative approaches to retaining as well as attracting key talent to achieve the ultimate goal of creating shareholder value in a fair manner.

The FASB's interpretation No. 44 (I44)[17] regarding repricings was retroactive to December 15, 1998.[18] Under I44, repricing a stock option is considered a modification of

[16] Levitt asked the National Association of Securities Dealers (NASD) to adopt the type of rule proposed by the New York Stock Exchange (NYSE) which would require shareholders' approval before awarding employees options grants. As of July 1, 2001, neither NYSE nor the Nasdaq requires its listed companies to seek shareholder approval for stock option plans if those plans apply to a large percentage of the companies' employees.

[17] The Interpretation No. 44 , *Accounting for Certain Transactions Involving Stock Compensation—An Interpretation of APB Opinion No. 25* is also intended to resolve the inconsistency between EITF Issue Nos. 87-33, *Stock Compensation Issues Related to Market Decline*, and 94-6, *Accounting for the Buyout*

the option that will cause the option to be subject to variable award accounting. If the exercise price of a fixed stock option award is reduced, the award shall be accounted for as variable from the date of the modification to the date the award is exercised, forfeited or expires unexercised. As a result, companies must mark-to-market all repriced options in each quarterly earnings report. The reported earnings will decrease as the intrinsic value of repriced options increases, whereas a subsequent decrease in intrinsic value will increase reported earnings.

In addition to the marking-to-market effect (or variable effect) mentioned above, companies will have to deduct the difference in value (or fixed effect) between the original stock options and the repriced options from their earnings when the repricing occurs. It is important to note that accounting costs and economic costs are not equivalent. For simplicity, we assume that the economic impact of those accounting charges on firm's terminal value is only shown as a tax deduction (or addition). The trade-off for a firm in repricing underwater options is between tax benefit and diluted share value, assuming that the firms' market values are not sensitive to reported earnings fluctuation.

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of Compensatory Stock Options, by requiring that all of the originally measured compensation be charged to expense at the time of a buyout.

[18] The provisions of I44 are effective July 1, 2000, and apply prospectively to new awards, exchanges of awards in a business combination, modifications to outstanding awards, and changes in grantee status that occur on or after that date. However, the standards also apply to repricings after December 15, 1998, and modifications to fixed stock option awards to add a reload feature apply to changes made after January 12, 2000.

For example, an executive has 10 vested stock options exercisable at $20 per share and the firm has 90 shares outstanding. The firm reprices those options when the stock has a quoted market price of $10 per share.[19] Later, but within the same tax year, the quoted market price of the underlying stock increases to $15 per share. At that time, the executive exercises those options. The fixed effect causes a $100 (=10 x $10) deduction from reported earnings and the variable effect causes additional $50 (=10 x $5). If the company faces a tax rate of 30%, the exercise generates a tax benefit for the company of $45 (= .30 x $150) and the number of outstanding shares is 100. The cash inflow of $45 is included in the terminal firm value in our model. In Section 3.4, we illustrate these effects in our model.

2.2 Rescission

According to the final SEC Staff Announcement No. D-93[20], if rescission occurs within the same tax year and prior to December 31, 2000, employees, especially top executives, can avoid the tax liability resulting from the exercise of their stock options. Furthermore, in some cases, the loans that companies made to executives so they could buy the stock are also being forgiven. Meanwhile, employers only record an additional compensation expense equal to the tax saving that the companies had foregone in the same year as a result of the rescission. In other words, the compensation cost is

[19] Assume that the options are repriced at-the-money (hence the new exercise price is $10 per share).

[20] See footnote # 5.

recognized only for the forgone tax benefit at the rescission date, but not for future increases in intrinsic value after that date.

In January 2001, the SEC staff provided the following example of a rescission transaction:[21]

> An employee has 1,000 nonqualified vested stock options exercisable at $5 per share. The employee exercises those options when the stock has a quoted market price of $50 per share. The exercise generates a tax liability to the individual of $15,000 and a tax benefit for the company of $15,000,[22] which the company records as a deferred tax asset or a reduction in current taxes payable. The stock issued to the employee is reflected in the financial statements as issued and fully paid-for shares. The employee does not sell the acquired shares.
>
> Later, but within the same tax year, the quoted market price of the underlying stock declines to $8 per share. At that time, the board of directors and the employee agree to "rescind" the exercise of the options. The company then issues 1,000 options with an exercise price of $5 per share and the same terms as the options originally exercised. In addition, the company returns to the employee the $5,000 exercise price previously

paid, the employee returns to the company any dividends received during the period the shares were outstanding, and the employee returns to the company the 1,000 shares held since they were issued upon the earlier exercise of the options.

For income tax purposes, both the company and the employee assert that the exercise and the subsequent rescission within the same tax year are treated as if neither had occurred. Therefore, the employee no longer owes any tax and the company has no tax benefit.

After January 1, 2001, the reinstated stock options are subject to "variable award" accounting treatment, thus requiring estimated compensation expenses. The rationale is that the rescission, in essence, grants employees a "put" to the company at a stock price that could be at other than "fair value." Such a repurchase feature results in variable award accounting until the exercise or expiration of the repurchase feature.[23] Put differently, the "marked-to-market" variable accounting means that the company must record an expense each quarter representing the current difference between the option price ($5 in the example mentioned above) and the market price of the shares, which could result in a substantial accounting charge. The process goes on until the options are no longer in effect, either because they have been exercised, have lapsed, or are forfeited.

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[21] See the SEC Staff Announcement Topic No. D-93, dated January 17-18, 2001.
[22] SEC assumes that both the employee and the company have 33 percent tax rates.
[23] FASB Interpretation No. 44 dated May 1, 2000 and EITF Issue No. 00-23.

Finally, the terms of the rescission must be reflected in the earnings-per-share report and included in the statement of changes of stockholder equity.[24] For instance, if a company enters into a rescission transaction similar to the example above, its basic EPS computation should reflect the dilution effect of the option exercise until it is rescinded.

Although the rescission practice has generated considerable controversy about whether it is just another way to eliminate the risk associated with options, it is not clear whether the practice's impact resulting from valuable tax deductions is economically significant. In retrospect, it would be interesting to know if the tax benefit to firms when their employees exercise options in a booming market contributes significantly to inflated earnings. On the other hand, it is not known just how common rescission has become since 1999 but it is predicted that companies may be very reluctant to adopt rescission after January 2001 because of the variable accounting charge. In any case, the SEC's guidance is apparently at odds with FASB staff recommendations, and FASB has not yet issued any guidance of its own on the subject other than to release the SEC guidance.[25]

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[24] The disclosure must be in accordance with generally accepted accounting principles, such as FASB Statements 123 (Accounting for Stock-Based Compensation) and FAS 128 (Earnings per Share).

[25] On February 1, 2001, the Financial Accounting Standards Board (FASB) released accounting guidance from the SEC.

3. The Model

We construct our model based upon the framework proposed by AJS. We analyze the dynamic optimality of rescuing underwater stock options from the viewpoints of both shareholders (called the "principal", collectively) and managers (called the "agent", collectively). The objective for the principal is to choose an initial option-based incentive contract to maximize his/her expected payoff in a situation where repricing and/or rescission of the agent's stock options are possible.

The agent needs to choose an optimal level of effort (or action) to maximize his/her expected terminal payoffs. Anticipating the agent's action, the principal selects an optimal initial option contract (in terms of the number of shares on the underlying stock) to maximize his/her expected initial payoffs given the agent's expected action and payoffs. The probabilistic distribution for the firm value depends on the agent's effort (denoted as a) as well as external factors (denoted as m) of which the agent has no control.

There is no information asymmetry: the expected terminal payoff structure and all probability distributions are common knowledge. Put differently, we analyze an ex-ante optimal option-based incentive contract offered by the principal and the best response from the agent after the probability of repricing or rescission of the agent's options is taken into account. Recall that there is a trade-off between tax benefits and diluted share value as a result of exercising repriced options.

The probability of underwater options being repriced (denoted as $\pi \in [0,1]$) is assumed to be exogenously determined[26] and both the principal and the agent know this probability distribution. For example, we will discuss in section 6 the ex-ante optimal option-based incentive contract offered by the principal if the probability of repricing is a function of the degree to which existing options are under water. Since Brenner, Sundaram and Yermack (2000) report that repricing is followed by a 40% drop, on average, in the strike price, it is interesting to investigate if there exists, from an ex-ante viewpoint, a threshold level of out-of-the-moneyness that optimally triggers repricings.

We also put emphasis on the influence of the agent's action, or efforts, in determining the likelihood of firm value in the subsequent period. The motivation for this emphasis is that defenders of repricing argue that poor performance prior to repricing is driven by external factors beyond the agent's control. To justify this argument, we will examine the influence of the agent's action or effort level, along with external factors, on the likelihood of having higher future firm value.

[26] The probability of underwater options being repriced can be associated with firm characteristics, stock market conditions, and appropriate measures of board independence. An empirical test of repricing determinants would be an interesting exercise but is outside of the scope of this paper.

3.1 Two-period Dynamic Model

We extend the model proposed by AJS to incorporate the economic impacts of the new accounting rulings associated with repricing and rescission. AJS find that *some* repricings are almost always optimal for the principal based on higher expected initial payoffs, even from an ex-ante standpoint. That conclusion is made without considering tax implications of new accounting rulings associated with direct repricings, which became effective after December 1998. As a result of these tax impacts and shareholder activism, the traditional repricing in which the exercise price is lowered to then-current market value has been losing its dominance as a solution to rescuing underwater options since 1998.[27] One goal we try to accomplish here is to rationalize the repricing phenomenon and justify the decision-making process of rescission.

It is helpful to refer to Figure 1 while going through our model description below. We assume that both the manager (the "agent") and the owners (the "principal") are risk-neutral. In the two-period model of firm value with dates indexed by t = 0, 1, 2, all payoffs are assumed to be received at the terminal date t = 2.[28] The terminal payoffs for each party at each state of economy are common knowledge. The repricing, if any, will

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[27] While direct repricing is diminishing as a remedy for underwater options, alternatives to direct repricing have gained in popularity over time. See Yang and Carleton (2002) for detailed analysis.

occur at t = 1, and no layoff and bankruptcy will occur throughout these two periods. We further assume that all discount rates are zeros to simplify the notation. Our intention is to capture the impacts of the agent's expected actions and the possible repricing in the interim period, including the continuation effect and feedback effect. The (positive) continuation effect results from higher level of effort by the motivated agent in the subsequent period and therefore generates higher terminal payoffs. On the other hand, the (negative) feedback effect is caused by lack of effort from the agent in the initial period because of the anticipation of repricing.

Therefore, our model in essence is a one-period model with an interim period in which possible occurrence of repricing or rescission is anticipated by both parties. In other words, the agent will choose an action (or effort level) in the interim period conditional on whether firm value increases (denoted as H state in Figure 1) or decreases (denoted as L state) from the initial stage to maximize his/her expected terminal payoff. Similarly, the agent selects an initial action at t = 0 to maximize his/her expected payoff in the interim period. Given the expected optimal response from the agent, the principal then chooses to offer, at time 0, $\alpha \in (0,1]$ options on the firm's terminal value to maximize his/her own expected terminal payoff. Note that if the agent exercises in-the-money options at t = 2, the number of outstanding shares is $(1+\alpha)$.

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[28] In an event of rescission, the payoff from exercising in-the-money options can occur at the interim date t = 1 and later on the already-exercised option can be rescinded at t = 2. To simplify the notation, we assume

Figure 1 illustrates the binomial structure of the model. At the beginning stage I, the principal hires an agent to run the firm whose only share's initial value is normalized to unity. The firm's value at t = 1 can be either H or L with probabilities P(H) = $q\ m + (1-q)\ a = 1 - P(L)$, where $H = 1 + u$, $L = 1 - u$, and $u \in (0,1)$. The action (or effort level) $a \in [0,1]$ is taken by the agent at node I. The parameters, m and $q \in [0,1]$, can be interpreted as the influence of external factors and the extent to which the agent's action may influence the likelihood of firm value in the subsequent period, respectively.

Through the optimization process described above, the expected optimal level of action chosen by the agent (a*) is known to the principal at the initial stage I. To keep our focus on the issues motivating this paper, we assume that m and q are common knowledge between the principal and the agent: they have the same expectation about m and q. In other words, firm value at the end of each period is jointly determined by external factors (m) of which the agent has no control and the agent's action (a) with probabilities of q and (1-q), respectively. Furthermore, if everything else remains constant, the lower the q is, the more control the agent has. Meanwhile, we define p(H) as above to emphasize the fact that the principal and the agent only observe the signals {H or L} without knowing the exact underlying cause. Based on the common expectations about m and q, the principal and the agent make their decisions accordingly. One interesting question we try to answer is how or whether the agent's control

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all payoffs are received at the terminal date t = 2.

(measured by $(1-q)$) over return distributions influence the decisions of granting initial incentive contract and of resetting the original contract.

Among three possible values at t = 2, HH = H^2, HL = LH, and LL = L^2, the fact that HL<1 by definition also accommodates the analysis when rescission is anticipated. Let $A = \{a_I, a_h, a_l\}$ be the agent's action vector. a_i is the action taken by the agent at node i, where $i \in \{I, H, L\}$. Let $W = \{w_{hh}, w_{hl}, w_{lh}, w_{ll}\}$ be the agent's terminal payoffs. If rescission is not considered, W is the compensation profile anticipated by the agent[29] or the intrinsic option value assuming the agent is compensated with stock options only. Note that W is predetermined given the terminal firm value in each of final states. Let $F = \{f_{hh}, f_{hl}, f_{lh}, f_{ll}\}$ be the principal's expected value per share in each of the terminal states. Note that the number of outstanding shares may be greater than one if the agent exercises his/her options. If the firm commits to not repricing or rescinding the options regardless of the firm's terminal value, then

$$f_{hh} = \frac{\mathrm{HH} + \alpha + \pi_c \alpha [\mathrm{HH} - 1]}{1 + \alpha}, \text{ where } \pi_c \text{ is the corporate tax rate.} \tag{3.1}$$

$$f_{hl} = \mathrm{HL}$$

$$f_{lh} = \mathrm{LH}$$

$$f_{ll} = \mathrm{LL}$$

[29] As pointed out by AJS, the anticipated compensation profile at time 2 need not be the same as that offered by the principal at time 0 if a repricing at time 1 is expected by the agent.

Note that the numerator on the right hand of equation (3.1) includes α (the price paid by the agent in exchange for additional α shares) and the tax benefit (= $\pi_c\alpha$ [HH-1]). For simplicity, we assume that only the tax benefit (or liability) resulting from the new accounting rulings has an economic impact on firm value. Personal taxes and other income taxes are ignored. Table 1 lists the principal's share values at the terminal date. Correspondingly, the agent's expected payoffs at the terminal date are

$$w_{hh} = \alpha\,(f_{hh} - 1) \qquad \text{and} \qquad w_{hl} = w_{lh} = w_{ll} = 0$$

since W is simply the intrinsic option value provided the agent is compensated only with stock options.

Table 2 lists the agent's expected terminal payoffs if α call options on firm's terminal value are granted at t = 0. Note that if a repricing at t = 1 is expected, the anticipated improvement of compensation profile may cause a negative feedback effect as far as incentives are concerned.

Not surprisingly, rescission does not change the agent's expected payoff profile at all if the "Do-nothing" column in Table 2 is compared with "Rescission" column or "Repricing" with "Repricing + Rescission" column.[30] In addition, the reinstated options

[30] The reason is that rescission, a tax-motivated strategy, is originally designed to rescue employees who would not have sufficient proceeds from selling the stock to pay the tax occurring after option exercise.

after rescission are worthless because we assume that all payoffs are received at the terminal date t = 2 and the options are out-the-money (since HL < 1).

3.2 The Agent's Best Response Problem

After the agent takes an action a, a public signal s $\in$ {H, L} is observed. After observing the signal, the agent chooses either a_h or a_l following signal H or L, respectively. Taking the action a in any period also results in a cost or disutility to the agent of $c(a) = \frac{1}{2}ka^2$, where k > 0. The assumed quadratic cost function emphasizes increasing marginal costs for the risk-neutral agent.

Given W and $A=\{a\ ,\ a_h\ ,\ a_l\}$, the agent's expected payoff at node H, denoted as U_h, is given by

$$U_h = \mathrm{p(H)}w_{hh} + \mathrm{p(L)}w_{hl} - c(a_h). \tag{3.2}$$

where $\mathrm{p(H)} = qm + (1 - q)a_h = 1 - \mathrm{p(L)}$ and H > 1 > L

Similarly, the expected payoff at node L is denoted as

$$U_l = \mathrm{p(H)}w_{lh} + \mathrm{p(L)}w_{ll} - c(a_l). \tag{3.3}$$

Thus, the agent's expected initial payoff given W and A is

$$U(a, U_h, U_l) = \mathrm{p(H)}\ U_h + \mathrm{p(L)}\ U_l - c(a). \tag{3.4}$$

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because of subsequent stock price declines. In section 4.2, we will take into account the agent's personal taxes while analyzing the optimality of rescission.

The agent's objective is to choose an optimal action set $A^* = \{a^*, a_h^*, a_l^*\}$ to respond to the anticipated offer W, which must satisfy:

$$a_h^* = \arg\max_{a_h} U_h(a_h, w_{hh}, w_{hl}). \qquad a_l^* = \arg\max_{a_l} U_l(a_l, w_{lh}, w_{ll})$$

If we let $U_h^* = U_h(a_h^*, w_{hh}, w_{hl})$ and $U_l^* = U_l(a_l^*, w_{lh}, w_{ll})$, the optimal initial action a^* is

$$a^* = \arg\max_{a} U(a, U_h^*, U_l^*).$$

3.3 The Principal's Choice of Incentive Contract

The main task for the principal is to choose a grant of α call options on the firm's terminal value at t = 0 to maximize his/her own initial expected payoff. Recall that we assume that the principal is risk-neutral and the principal-agent relationship will last the full two periods. If the principal grants the agent an initial compensation offer and commits to not altering the contract throughout the periods regardless of market conditions, the principal's expected payoff at node H, denoted as V_h, is given by

$$V_h = p(H) f_{hh} + p(L) f_{hl} \tag{3.5}$$

where $F = \{f_{hh}, f_{hl}, f_{lh}, f_{ll}\}$ is the principal's expected value per share in each of terminal states. Similarly, expected payoff at node L is denoted as V_l.

$$V_l = p(H) f_{lh} + p(L) f_{ll} \tag{3.6}$$

Thus, the principal's expected payoff at t = 0 is

$$V(\alpha, V_h, V_l) = p(H) V_h + p(L) V_l. \tag{3.7}$$

The principal's objective is to choose an initial grant, α^*, to maximize his/her expected payoff at t = 0, knowing the agent's compensation profile W and expected actions $A^* = \{a^*, a_h^*, a_l^*\}$.

Note that the probability (π) of underwater options being repriced at node L is assumed to be exogenously determined with both the principal and the agent having the same expectation about π. We will discuss in Section 6 the ex-ante optimal option-based incentive contract offered by the principal if π is a function of degree to which existing options are under water (measured by u). We let π be a function of the agent's action and examine an argument claimed by shareholder activists: repricing may not be a value-maximizing but a self-serving strategy by an executive-friendly board.

3.4 The Terminal Payoff Structure

Table 2 lists the agent's terminal payoffs $W = \{ w_{hh}, w_{hl}, w_{lh}, w_{ll} \}$ if initial α call options on firm's terminal value are granted. Note that HL = LH <1. This simplification enables us to focus on the discussion of rescission without qualitatively changing our results. We also assume that the options are granted at-the-money (hence the exercise price is unity) as the majority of firms have done in practice.[31]

[31] See Brenner, Sundaram, and Yermack (2000) for example.

Table 1

The principal's expected share values at the terminal date.

Scenarios	Do Nothing[1]	Repricing[2]	Rescission[3]	Repricing + Rescission
f_{hh}	$\frac{HH+\alpha+\pi_c\alpha[HH-1]}{1+\alpha}$	$\frac{HH+\alpha+\pi_c\alpha[HH-1]}{1+\alpha}$	$\frac{HH+\alpha+\pi_c\alpha[HH-1]}{1+\alpha}$	$\frac{HH+\alpha+\pi_c\alpha[HH-1]}{1+\alpha}$
f_{hl}	HL	HL	$HL + \pi_c\, \alpha(1-HL)$ [4]	$HL + \pi_c\, \alpha(1-HL)$
f_{lh}	LH	$\frac{LH+\alpha L+B_R}{1+\alpha}$ *	LH	$\frac{LH+\alpha L+B_R}{1+\alpha}$
f_{ll}	LL	$LL + \pi_c\alpha[(1-L)+(LL-L)]$	LL	$LL + \pi_c\alpha[(1-L)+(LL-L)]$

* B_R ($= \pi_c\alpha[(1-L)+(LH-L)]$) is the tax benefit resulting from the accounting charges associated with repricing, where π_c is the corporate tax rate.

1. Do-nothing occurs when the firm commits to not repricing or rescinding the options regardless of the firm's terminal value. Note that in this case the options are in-the-money only at node HH.

2. Repricing occurs at node L; reset the exercise price to L for all α options.

3. The agent exercises the options at node H and the principal rescinds the already-exercised options (or equivalently buys back α shares at a price of unity) at node HL. To simplify the notation, we assume all payoffs are received at the terminal date t = 2.

4. Since the reinstated options after rescission are subject to variable accounting charges, the principal receives a tax benefit, $\pi_c\, \alpha(1-HL)$, at node HL.

Table 2

The agent's terminal payoffs if initial α call options on firm's terminal value are granted.

Scenarios	Do Nothing[1]	Repricing[2]	Rescission[3]	Repricing + Rescission
w_{hh}	$\alpha(f_{hh} - 1)$*	$\alpha(f_{hh} - 1)$	$\alpha(f_{hh} - 1)$	$\alpha(f_{hh} - 1)$
w_{hl}	0	0	0	0
w_{lh}	0	$\alpha(f_{lh} - \mathrm{L})$	0	$\alpha(f_{lh} - \mathrm{L})$
w_{ll}	0	0	0	0

* Note that personal taxes are ignored and that the options are granted at-the-money (hence the exercise price is unity).

1. Do-nothing occurs when the firm commits to not repricing or rescinding the options regardless of the firm's terminal value. Note that in this case the options are in-the-money only at node HH.

2. Repricing occurs at node L; reset the exercise price to L for all α options.

3. The agent exercises the options at node H and the principal rescinds the already-exercised options (or equivalently buys back α shares at a price of unity) at node HL. To simplify the notation, we assume all payoffs are received at the terminal date t = 2 and personal taxes are ignored.

Except in rescission, W is simply the intrinsic option value provided the agent is compensated only with stock options. For instance, the agent expects $w_{lh} = \alpha (f_{lh}$ -L) if repricing occurs at node L. f_{hh} is the diluted share value and L is the share price paid by the agent. In rescission, however, W represents the agent's terminal payoffs from the acquired shares at node H or the unexercised options. For example, the agent expects $w_{hh} = \alpha (f_{hh} - 1)$ if the agent exercises the options at node H at a price of unity and at the end (t = 2) the acquired shares are worth f_{hh} each. On the other hand, if the principal rescinds the already-exercised options (or equivalently buys back the shares at a price of unity) at node HL, the agent expects $w_{hl} = 0$ because the rescission treats the previous exercise as if it had never occurred. Since HL<1, $w_{hl} = 0$ and f_{hl} = HL.

Table 1 lists the principal's expected share value at t = 2. In the case of repricing, for example, the principal's expected payoff (or share value) at node LH is

$$f_{lh} = \frac{\mathrm{HH}+\alpha\,\mathrm{L}+\mathrm{B_R}}{1+\alpha}$$

Note that $B_R = \pi_c \alpha$ [(1-L) + (LH-L)]. α (1 - L) is the "fixed effect", deducted at node L since the firm will have to deduct the difference in value between the original stock options and the repriced options from its earnings when the repricing occurs. The "variable effect" (or "marking-to-market effect"), α (LH-L), is posted on the repriced options at node LH. Note that the corresponding variable charge at node LL, α(LL - L), is negative, reflecting the feature of marking-to-market.

In the case of rescission, since the reinstated options after rescission are subject to variable accounting charges, the principal receives a tax benefit, $\pi_c\ \alpha$ (1- HL), at node HL without improving the agent's expected terminal payoffs. However, we need to point out that our two-period model neither captures the continuation effect of rescission, if any, beyond the terminal date (t = 2) nor considers the costs of replacing the agent. We will discuss this consideration in Section 6.

3.5 Equilibrium under Do-nothing

First, we derive an equilibrium for our benchmark strategy, do-nothing, in which repricing and rescission of the initial award are ruled out. The principal grants the agent an initial compensation offer and commits to not altering the contract later regardless of market conditions. Since the majority of executive stock options are issued at-the-money (see Brenner, Sundaram, and Yermack (2000)), we will assume that any initial options awarded by the principal carry an exercise price of unity.

Under the do-nothing strategy, the agent's best responses $A(\alpha) = \{a, a_h, a_l\}$ are

$$\begin{cases} a_l = 0, \\ a_h(\alpha) = \min\{1, \alpha(1-q)(f_{hh}-1)/k\}, \\ a(\alpha) = \min\{1, (1-q)\, U_h(\alpha)/k\} \end{cases} \tag{3.8}$$

where $$f_{hh} = \frac{\mathrm{HH} + \alpha + \pi_c \alpha [\mathrm{HH} - 1]}{1 + \alpha}$$ (π_c: corporate tax rate)

$$U_h(\alpha) = [\, p(a_h(\alpha))\,][\, \alpha(f_{hh} - 1)\,] - \frac{1}{2} k\, [a_h(\alpha)]^2$$

Proofs of the results are provided in the Appendix A.1.

The principal's expected payoffs at nodes H and L, are given by equations (3.5) and (3.6), respectively. Then the principal's expected initial payoff given W and $A(\alpha)$ is

$$V(\alpha, V_h, V_l) = p(a)\, V_h + [1 - p(a)]\, V_l$$

The principal's objective is to choose an initial grant, α^*, to maximize his/her initial expected payoff, given the agent's compensation profile W and expected actions $A(\alpha) = \{a, a_h, a_l\}$.

4. Equilibrium under Repricing or Rescission

Subsections 4.1 and 4.2 will establish equilibria for repricing and rescission, respectively. To keep our focus on underwater options, we assume that repricing only occurs when the options are out-of-the-money (e.g., at node L) with a probability of π. When repricing takes place, all existing options (α) are reset at a new exercise price of L, meaning the renewed options are issued at-the-money. In practice, repricing almost always occurs when options are under water; resetting the contracts when options are in the money is virtually non-existent. In the case of rescission, we assume the agent exercises the options at node H and the principal rescinds the already-exercised options (or equivalently buys back α shares at a price of unity) at node HL. For simplicity, we assume all payoffs are received at the terminal date t = 2.

4.1 Equilibrium under Repricing

To make our model closer to reality, we assume that the probability of repricing at node L is $\pi \leq 1$, which as discussed previously, is exogenously determined and known to both parties. The probability π may depend upon how market will respond to repricing, how deeply the options will be under water, and how strongly shareholders will vote against repricing if shareholders' approval is required. The principal (or compensation committee) has no control over these exogenous factors. In particular, we assume that π

= u, which indicates how deeply the options are under water. Recall that L = 1 - u and u $\in$ (0,1). However, it is also reasonable to relate the probability π to some endogenous factors such as firm characteristics, board independence, and executives' influence in the decision-making process. Although it is not in our model, making this parameter (π) endogenous results in interesting inferences about the role of board of directors as well as the optimality of repricing.[32]

Appendix A.2 shows that if repricing is considered at node L with a probability of π, the agent's best responses $A(\alpha) = \{a, a_h, a_l\}$ are

$$\begin{cases} a_l(\alpha) = \min\{1, \alpha\,\pi\,(1\text{-}q)(f_{lh}\text{-L})/k\}, \\ a_h(\alpha) = \min\{1, \alpha\,(1\text{-}q)(f_{hh}\text{-}1)/k\}, \\ a(\alpha) = \min\{1, (1\text{-}q)\,[U_h(\alpha) - U_l(\alpha)]/k\} \end{cases} \tag{4.1}$$

where
$$f_{lh} = \frac{\text{LH}+\alpha\,\text{L}+\text{B}_\text{R}}{1+\alpha},$$

$$\text{B}_\text{R} = \pi_c\alpha\,[\,(1\text{-L}) + (\text{LH-L})\,],$$

$$f_{hh} = \frac{\text{HH}+\alpha+\pi_c\alpha\,[\text{HH}-1]}{1+\alpha}, \qquad (\pi_c\text{: corporate tax rate})$$

$$U_l(\alpha) = \pi\,[\,p(a_l(\alpha))\,][\,\alpha\,(f_{lh}\text{-L})\,] - \frac{1}{2}k[a_l(\alpha)]^2, \text{ and}$$

$$U_h(\alpha) = [\,p(a_h(\alpha))\,][\,\alpha\,(f_{hh}\text{-}1)\,] - \frac{1}{2}k[a_h(\alpha)]^2$$

[32] See Yang and Carleton (2002) for details.

Note that B_R is the tax benefit resulting from the accounting charges associated with repricing. Proofs of the results are provided in the Appendix A.2.

We use superscripts N and R to denote no-repricing and repricing, respectively. For instance, at node L, the agent needs to choose a_l to solve

$$\max_{a_l \in [0,1]} \{\pi U_l^R + (1-\pi) U_l^N\}$$

where $U_l^R = p(a_l)[\alpha(f_{lh} - \mathrm{L})] + (1-p(a_l))[0] - \frac{1}{2} k a_l^2$,

$U_l^N = p(a_l)[0] + (1-p(a_l))[0] - \frac{1}{2} k a_l^2$, $\quad p(a_l) = qm + (1-q)a_l$

$$f_{lh} = \frac{\mathrm{HH} + \alpha\,\mathrm{L} + \mathrm{B_R}}{1+\alpha}, \qquad \text{and} \qquad \mathrm{B_R} = \pi_c \alpha [(1\text{-L}) + (\text{LH-L})].$$

As for the principal, his/her continuation payoffs $V_h(\alpha)$ and $V_l(\alpha)$ are given by

and
$$\begin{cases} V_h(\alpha) = [p(a_h(\alpha))] f_{hh} + [1 - p(a_h(\alpha))] f_{hl} & (4.2) \\ V_l(\alpha) = \pi V_l^R + (1-\pi) V_l^N & (4.3) \end{cases}$$

where $f_{hl} = \mathrm{HL}$

$V_l^R = p(a_l) f_{lh} + (1-p(a_l)) f_{ll}$

$V_l^N = p(a_l)[\mathrm{LH}] + (1-p(a_l))[\mathrm{LL}]$, $\quad p(a_l) = qm + (1-q)a_l$

$$f_{lh} = \frac{HH+\alpha\, L+B_R}{1+\alpha}, \text{ and } \quad B_R = \pi_c\alpha\,[\,(1\text{-}L) + (LH\text{-}L)\,].$$

$$f_{ll} = LL + \pi_c\alpha\,[\,(1\text{-}L) + (LL\text{-}L)\,].$$

Given the agent's optimal response, equation (4.1), to an initial offer of α, the principal now chooses α to maximize his/her initial expected payoff:

$$\max_{\alpha\in[0,1]} \{[\,p(a(\alpha))]V_h(\alpha) + [1 - p(a(\alpha))]V_l\} \tag{4.4}$$

4.2 Equilibrium under Rescission

In case of rescission, we assume, without loss of generality, the agent exercises the options at node H and the principal will rescind the already-exercised options (or equivalently buys back α shares at a price of unity) at node HL with a probability of u. Recall that u indicates how deeply the options are under water at the end of Period 1 (for example, L = 1 - u and u $\in$ (0,1)). For simplicity, we assume all payoffs are received at the terminal date t = 2.

As a tax-motivated strategy, rescission is designed to rescue employees who would not have sufficient proceeds from selling the stock to pay the tax occurring after option exercise, because of subsequent stock price declines. Hence, we take personal tax into account while analyzing the optimality of rescission. For simplicity, we assume that the agent's personal tax rate is the same as the corporate tax rate (π_c).

The exercise at node H generates a tax liability to the agent of $T = \pi_c \alpha(H-1)$ and a tax benefit for the principal of same amount, which the company records as a deferred tax asset or a reduction in current taxes payable. The payoffs under rescission for the principal and the agent are listed in Tables 3 and 4, respectively. The dynamic optimization procedure for solving the principal's ex-ante contracting problem is analogous to the one under repricing. First, we use superscripts N and R to denote no-rescission and rescission, respectively. For instance, at node H, the agent needs to choose a_h to solve

$$\max_{a_h \in [0,1]} \{\pi U_h^R + (1-\pi) U_h^N\} \tag{4.5}$$

where $U_h^R = p(a_h)[\alpha f_{hh} - \alpha - T] + (1-p(a_h))[0] - \frac{1}{2} k a_h^2$,

$U_h^N = p(a_h)[\alpha f_{hh} - \alpha - T] + (1-p(a_h))[\alpha f_{hl} - \alpha - T] - \frac{1}{2} k a_h^2$,

$p(a_h) = qm + (1-q)\, a_h$, $\quad T = \pi_c \alpha (H-1)$

$f_{hh} = \dfrac{HH + \alpha + T}{1+\alpha}$, and $f_{hl} = \dfrac{HL + \alpha + T}{1+\alpha}$.

This leads to the following solution

$$a_h(\alpha) = \begin{cases} min\{1, \frac{1-q}{k}[\,\alpha(f_{hh} - f_{hl}) + \pi(\alpha f_{hl} - \alpha - \mathrm{T})\,]\,\} & \text{if } \alpha > \pi(\alpha + \mathrm{T})/[f_{hh} - (1-\pi)f_{hl}] \\ 0 & \text{otherwise} \end{cases} \quad (4.6)$$

Thus, the agent's continuation payoff $U_h(\alpha)$ at node H is given by

$$U_h(\alpha) = [p(a_h(\alpha))][\alpha f_{hh} - \alpha - \mathrm{T}] + (1-\pi)[1 - p(a_h(\alpha))][\alpha f_{hl} - \alpha - \mathrm{T}] - \frac{1}{2}k[a_h(\alpha)]^2 \quad (4.7)$$

Proofs of the results under rescission are provided in the Appendix A.3.

Table 3

The agent's terminal payoffs if initial α call options are exercised at node H.

Scenarios	Do Nothing[1]	Rescission[2]
w_{hh}	$\alpha(f_{hh} - 1) - T$	$\alpha(f_{hh} - 1) - T$
w_{hl}	$\alpha(f_{hl} - 1) - T$	0
w_{lh}	0	0
w_{ll}	0	0

Table 4

The principal's net terminal payoffs if initial α call options are exercised at node H.

Nodes	Do Nothing	Rescission[2]
HH	F_{hh}	f_{hh}
HL	F_{hl}	$HL + \pi_c\, \alpha(1 - HL)$ [3]
LH	LH	LH
LL	LL	LL

* Note that personal taxes are considered and the options are granted at-the-money (hence the exercise price is unity). $T = \pi_c \alpha (H-1)$ is the tax liability as a result of exercising options at node H. Note that T is also the tax benefit for the principal, which the company records as a deferred tax asset or a reduction in current taxes payable. f_{hh} is the expected share value at node HH, which is equal to $\frac{HH + \alpha + T}{1+\alpha}$. Similarly, $f_{hl} = \frac{HL + \alpha + T}{1+\alpha}$.

1. Do-nothing occurs when the firm commits to not rescinding the options regardless of the firm's terminal value. Note that in this case the options are in-the-money only at node HH.

2. The agent exercises the options at node H and the principal rescinds the already-exercised options (or equivalently buys back α shares at a price of unity) at node HL. To simplify the notation, we assume all payoffs are received at the terminal date $t = 2$ and personal tax rate is the same as corporate tax rate.

3. Since the reinstated options after rescission are subject to variable accounting charges, the principal receives a tax benefit, $\pi_c\, \alpha(1 - HL)$, at node HL. Note that f_{hl} is greater than $HL + \pi_c\, \alpha(1 - HL)$.

5. Results

In this section, we summarize the influence of the parameters of interest on the principal's expected initial payoff (V) in equilibrium and on the optimal initial option grant (α) under three strategies: do-nothing, repricing, and rescission in subsections 5.1, 5.2, and 5.3, respectively.

5.1 Do-nothing

Figures 2 and 3 summarize the influence, under the do-nothing strategy, of the parameters of interest on the principal's expected initial payoff (V) in equilibrium and on the optimal initial option grant (α). Recall that k is the cost parameter for the agent's cost function (= $\frac{1}{2}ka^2$) and the likelihood of higher firm value in next period is p(H) = $q\ m$ + (1-q) a. The parameter m represents the influence of external factors on p(H). The influence of the agent's action or effort level (a) on the likelihood of having higher future firm value is measured by (1 - q): *ceteris paribus*, the lower the q is, the more control the agent has.

5.1.1 The Cost Parameter for the Agent's Cost Function (k): Higher k, Lower V

Panels (A) and (B) in Figure 2 show the effect of the cost parameter for the agent's cost function on the principal's expected payoff (V) and on the optimal initial option grant (α). When k is low (for example, $k < 0.2$ in Panel (B)), V decreases and α increases as k increases. When $k > 0.2$, the principal is worse off in terms of expected initial payoffs as k increases while offering maximal amount of options ($\alpha = 1$). The reason is that high-cost agents give less effort at the initial stage and the high-value stage (H). Note that, at the low-value stage (L), no agents have any incentive to give any effort because their options are worthless anyway.

5.1.2 The Influence of External Factors (m): Higher m, Higher V

Panels (C) and (D) in Figure 2 show that given k, the principal will have a higher expected initial payoff for providing smaller amount of options if the agent's action has a larger impact (indicated by a smaller q) on the likelihood of being in the high-value state (H). In other words, the options are worth more to the agent if the probability of being in the high-value state is more likely influenced by the agent's action than by some external factors (measured by m). As for the influence of external factors, as indicated in Panel (C), V increases and α remains nearly constant ($\alpha \approx 1$) before decreasing as m increases. This means that if the firm's value is more likely to increase because of some external factors, the principal's expected payoff will increase without granting more options to induce the agent's effort.

5.1.3 The Influence of the Agent's Actions (q): Lower q, Higher V

Panel (E) in Figure 2 shows that the principal's expected payoff (V) decreases and the option grant (α) increases as q increases until a local minimum (or maximum) is reached for V (or α), respectively. The intuition is that if the agent expects that his/her effort is not as important as external factors (indicated by a higher q) in determining the likelihood of reaching a high-value state, p(H), more options are needed to provide the agent with incentives. Hence, the principal's expected payoff decreases as a result of dilution. This pattern will continue until q reaches the point where the benefit from the agent's efforts is less than the cost of inducing those efforts. Meanwhile, as q increases, the increasing contribution from external factors on p(H) improves the principal's welfare regardless of the agent's efforts. That is why there is a U-shaped pattern for the principal's expected payoff in Panels (E) and (G). However, if no external factors influence p(H), or p(H) is a function of the agent's effort only, one can see in Panel (F) that V monotonically decreases and α increases monotonically as q increases.

5.1.4 The Variability of Possible Outcomes (u): Higher u, Higher V

Figure 3 shows the relationship between the principal's optimal decision (α) and the variability of possible outcomes (u). Intuitively, Panels (A) and (B) illustrate that the principal will offer fewer (options) while expecting more initial payoff in a volatile environment in which options are more valuable or the potential upside reward provides enough incentives for the agent. Not surprisingly, if the cost (or disutility) of the agent's efforts is higher, the principal will offer more (options) while expecting less initial payoff, as we compare Panel (C) to (A) or Panel (D) to (B).

The spread between two possible outcomes (H or L) at the end of period 1 is $2u$ by assumption. *Ceteris paribus*, a higher u leads to a higher volatility of the firm's market value. Let σ^2 be the variance of the firm's market value at t = 1. A simple calculation shows that $\sigma^2 = 4u^2\text{p}(1\text{-p})$, where $\text{p} = q\ m + (1\text{-}q)\ a$, is the probability of being a high-value state at t = 1. The maximal σ^2 is reached at $a = 0.5$ if m = 0.5 and q = 0 or $q = 0.5$.

In Panels (E) through (H), we see that the agent's optimal initial action (or effort level), a^* is an increasing function of u as we expect. Recall that a^* is chosen to maximize the agent's expected initial payoff. It turns out that under some conditions, a^* maximizes not only the agent's expected initial payoff but also the variance of the firm's market value at t = 1. For example, Panel (H) shows that the high-cost (k = 0.3) and influential (q = 0) agent will choose a^* = 0.5 when u = 0.2 to maximize his/her expected initial payoff while achieving maximal volatility of the firm's market value at t = 1. For a less influential agent (i.e., q = 0.5 as indicated in Panel (G)), it takes a wider spread between two possible outcomes to induce an a^* which can maximize both the expected initial payoff and the volatility of firm value at t = 1 (e.g., $u \approx 0.4$ when q = 0.5 and k = 0.3 as in Panel (G)). More interestingly, if we combine Panels (B) and (F), we see that the principal's expected initial payoff increases as u increases with fewer options being offered and the agent's optimal initial effort remaining maximal (a^* = 1).

5.2 Repricing

Figure 4 shows that from an ex-ante viewpoint, the principal is worse off in terms of expected initial payoffs under repricing than under do-nothing especially when k is high or the influence of external factors (represented by m) is high. However, Table 6 indicates that the principal, on average, has a higher expected initial payoff under repricing, although the difference is not statistically significant.

We use superscripts N and R to denote do-nothing and repricing, respectively. Figure 4 shows the influence of the parameters of interest on the difference of the principal's expected payoff (denoted as $V^{R\text{-}N}$) in equilibrium and on the difference of optimal initial option grant (denoted as $\alpha^{R\text{-}N}$) when repricing occurs at node L with a probability equal to one. From an ex-ante standpoint, a positive (or negative) $V^{R\text{-}N}$ indicates that the principal will be better (or worse) off under the repricing strategy than under the do-nothing strategy. We set u = 0.2 and the corporate tax rate, π_c = 0.34. Recall that k is the cost parameter for the agent's cost function ($c(a) = \frac{1}{2}ka^2$) and the likelihood of higher firm value in next period is $p(H) = q\,m + (1\text{-}q)\,a$.

5.2.1 The Cost Parameter for the Agent's Cost Function (*k*): Higher *k*, Higher *V*

If repricing is considered almost certainly (π = 1), Panels (A) and (B) in Figure 4 show the effect of the cost parameter for the agent's cost function on the principal's expected payoff and on the optimal initial option grant. When $m = q = 0.5$ as in Panel (A), the principal is better off in terms of expected initial payoffs under repricing than under do-nothing if the cost parameter (k) is greater than 0.15 while offering the same amount of options to begin with. The sensitivity in $V^{R\text{-}N}$ to the difference of the agent's expected initial payoff (denoted as $U^{R\text{-}N}$) is 0.2245, on average. It means that under repricing, the principal will expect an increase of 22.45 cents per dollar increase in the agent's expected initial payoff. The dominant repricing strategy becomes more dominant when k is high (i.e., $k > 0.3$) and the likelihood of higher firm value in the next period, p(H) is a function of the agent's effort (a) only, as indicated in Panel (B). When $k < 0.3$, $V^{R\text{-}N}$ is negative, meaning the principal is worse off under repricing.

According to these results, repricing seemingly restores incentive-alignment for underwater options for high-cost agents. However, as indicated in Panel (B), for low-cost agents, the principal will offer more options initially and have a lower expected initial payoff if repricing is anticipated with certainty. Put differently, when $q = 0$, the principal is better off under repricing only if the cost parameter $k \geq 0.3$. When $k \geq 0.3$, repricing dominates do-nothing by having the same amount of initial option grant but higher principal's expected payoff. This result is consistent with Acharya, John, and Sundaram (2000) which is a special case of ours when $q = 0$.

5.2.2 The Influence of External Factors (m): Constant on α but Negative on V

Panel (C) in Figure 4 shows that given $k = 0.1$ and $q = 0.5$, the principal will offer the same amount of options and have higher expected initial payoffs under a sure repricing policy if $m < 0.4$. However, the difference in the principal's expected initial payoffs decreases as the influence of external factors (measured by m) increases. It is trivial that if the agent's action is the sole factor in determining the likelihood of being in the high-value state (H), for example $q = 0$ in Panel (D), the external factors make no difference between repricing and no-repricing.

5.2.3 The Influence of the Agent's Actions (q): $\alpha \geq 0$ if $q = 0$

The question we try to answer here is how or whether the agent's control (measured by q) over return distributions influences the decisions to grant the initial incentive contract and to reset the original contract. Recall that the lower q is, the more control the agent has on the likelihood of reaching the high-value (H) state: p(H) = $q\ m + (1-q)\ a$ = 1-p(L), where H = $1 + u$, L = $1 - u$, and $u \in (0,1)$.

Panels (E) through (H) in Figure 4 show that when the agent's action (a) is the sole factor in determining the likelihood of being in the high-value state (q = 0), the initial options granted under a sure repricing policy are no less than those under the do-nothing policy. Meanwhile, the principal will be better off in terms of expected initial payoffs under do-nothing than under repricing if k is low (i.e., k = 0.1 as indicated in Panels (E) and (F)). The opposite is true when k is high (i.e., k = 0.3 as indicated in Panels (G) and (H)).

Panels (E) through (H) in Figure 4 also show a nonlinear relationship between the difference of the principal's expected payoff (denoted as V^{R-N}) in equilibrium and the agent's control (measured by q) over return distributions. Nonetheless, Panels (G and (H) in Figure 4 show that the dominance of repricing k is high as indicated. On the other hand, when m = 0.5 and k = 0.1 as in Panel (E), repricing is dominated by do-nothing because of non-negative α^{R-N}'s and non-positive V^{R-N}'s. A non-negative α^{R-N} over the range of q means that the principal will grant the same amount of, if not more, options initially if repricing almost certainly occurs at node L.

Panel (F) shows that the difference of optimal initial option grant, $\alpha^{R\text{-}N}$, increases first and then declines as q increases. If the agent's effort is not as important as external factors (i.e., $q > 0.5$) in determining the likelihood of being a high-value state, p(H), fewer options will be granted initially if repricing occurs at node L with a probability equal to one than if external factors are more important than the agent's effort.

The intuition is that the expected repricing causes a positive continuation effect, which outweighs the negative feedback effect also caused by the expected repricing. In other words, the incentive provided by initial options increases if repricing is expected. Consequently, the principal's expected payoff under repricing increases as a result of increased incentive. This pattern will continue until q reaches the point where the negative feedback effect of repricing is equal to the positive continuation effect of repricing. After that, it makes no difference for the principal to reprice or not to reprice underwater options.

5.2.4 The Variability of Possible Outcomes (u): Higher u, Higher V

Figure 5 shows the impact of the variability of possible outcomes (measured by u) on the principal's optimal compensation decision (α) and on the principal's expected initial payoff (V). Panels (A) through (D) in Figure 5 are almost identical to the corresponding panels in Figure 3. There is little difference between repricing and do-nothing in terms of the impact of the variability of possible outcomes, measured by u. However, Panels (E) through (H) in Figure 5 show that the agent's optimal initial action (or effort level), a^* under repricing is less than or equal to that under no-repricing.

Figure 6 shows the effects of the parameters of interest on the principal's expected payoff and on the optimal initial option grant when repricing is anticipated with a probability of 0.2. Each panel in Figure 6 shows patterns almost identical to those in the corresponding panel in Figure 4.

5.3 Rescission

Recall that as a tax-motivated strategy, rescission is not designed to provide or align incentives. Hence, rescission is not expected to influence the decision of granting an initial incentive contract. We use superscripts N and R to denote do-nothing and rescission, respectively. Figure 7 shows the influence of the parameters of interest on the difference of the principal's expected payoff (denoted as $V^{R\text{-}N}$) in equilibrium and on the difference of optimal initial option grant (denoted as $\alpha^{R\text{-}N}$) when rescission occurs at node HL with a probability equal to one. Again, from an ex ante standpoint, a positive (or negative) $V^{R\text{-}N}$ indicates that the principal will be better (or worse) off under the rescission strategy than under the do-nothing strategy.

Interestingly, both the principal and the agent in many cases are better off in terms of expected initial payoffs under rescission than under do-nothing regardless of the cost parameter (k), the influence of external factors (m), and the influence of the agent's actions (q). One explanation, based on Figure 7, is that the principal anticipates the tax benefits and positive cash flows resulting from option exercises at node H if no rescission occurs at node HL. Therefore, the principal will grant as many options as he or she can offer at the initial stage ($\alpha^{N} \approx 1$). As a result, we see little effect on the principal's initial incentive contract decision ($\alpha^{R\text{-}N} \approx 0$), a higher level of effort from the agent at the initial stage (higher a^*), and the negative feedback effect at stage H (lower a^*_h). On average, the agent will almost always be better off under a sure rescission policy in terms of expected initial payoffs than under do-nothing while the principal is indifferent.

5.3.1 The Cost Parameter for the Agent's Cost Function (k): Higher k, Higher V if $q = 0$.

If rescission is considered a sure thing, Panels (A) and (B) in Figure 7 show the effect of the cost parameter for the agent's cost function on the principal's expected payoff and on the optimal initial option grant. As mentioned above, the optimal initial option grant does not change much because of rescission. The impact of the agent's cost parameter on the principal expected initial payoff depends on the agent's influence on the likelihood of being in the high-value state (measured by q). When $q = 0.5$ as in Figure 7:

Panel (A), the principal is worse off under rescission than under do-nothing if $k \geq 0.25$. When the agent's action is the sole factor in determining the likelihood of being in the high-value state ($q = 0$ as in Panel (B)), the principal is better off under rescission than under do-nothing if $k \geq 0.25$. The question here is whether the effect of increased initial incentive outweighs the effect of the decreased incentive at stage H. If yes (no), the principal is better (worse) off. Then, the next question is how the parameters of interest, such as k and q, change the balance between these two effects. For instance, the principal will be better off under rescission if he or she hires a high-cost agent whose action is the sole factor in determining the likelihood of being in the high-value state.

5.3.2 The Influence of External Factors (m): Constant on α but Negative on V

Panel (C) in Figure 7 shows that given $k = 0.1$ and $q = 0.5$, the principal will offer the same amount of options and have higher expected initial payoffs under a sure rescission policy if $m < 0.7$. However, the difference in the principal's expected initial payoffs decreases as the influence of external factors (measured by m) increases. It is trivial that if the agent's action is the sole factor in determining the likelihood of being in the high-value state (H), for example $q = 0$ in Panel (D), the external factors make no difference between rescission and no-rescission.

5.3.3 The Influence of the Agent's Actions (q)

Recall that the lower the q is, the more control the agent has on the likelihood of reaching the high-value (H) state. The result based on Figure 7 is threefold. First, the agent's control (measured by q) over return distributions does not change the decision to grant the initial incentive contract except when q is too low ($q = 0.1$) or too high ($q = 0.8$) as indicated in Panel (E). Second, if $q \approx 0.8$ and rescission will occur at node HL for sure, the principal will offer fewer options initially while expecting same initial payoff. Third, if the agent exercises options at node H and rescission occurs at node HL, the principal will probably only hire an agent whose action has greater influence ($q \leq 0.7$) on the probability of reaching the high-value state (H) than do external factors (measured by m).

Panels (E) through (H) in Figure 7 show non-negative $V^{R\text{-}N}$'s, indicating that the principal is better off in terms of expected initial payoffs under rescission. If the principal hires a low-cost agent (i.e., $k = 0.1$ as indicated in Panels (E) and (F)), fewer options will be granted initially under rescission when $q < 0.2$. If a high-cost agent (i.e., $k = 0.3$ as indicated in Panels (G) and (H)) is hired, the principal will offer the same amount of options as that under do-nothing. On average, the principal will be better off hiring a low-cost agent.

On the other hand, Panels (E) and (G) show that the difference of optimal initial option grant, $\alpha^{R\text{-}N}$, decreases first and then increases as q increases. If the agent's effort is not as important as external factors (i.e., $q > 0.7$) on determining the likelihood of being a high-value state, p(H), fewer options will be granted initially if rescission will occur at node HL for sure than if external factors are more important than the agent's effort.

The intuition is that the principal will offer more options to realize the tax benefits and positive cash flows resulting from option exercises at node H as assumed, before considering rescission. Our results show that the negative feedback effect caused by rescission is offset by the increased initial incentive only for the high-cost agent (high k) whose influence is relatively high ($q \leq 0.5$). In other words, the principal expects to induce a higher level of initial effort from the agent to offset the negative impact caused by rescission, a tax-motivated strategy, at stage H only if doing so is relatively cheap and worthwhile. Otherwise, the principal's expected payoff under rescission decreases as a result of increased incentive and lost tax benefit. This pattern will continue until q reaches the point where the agent's effort in determining the probability of reaching the high-value state (H) is as important as external factors (i.e., $q \leq 0.5$).

5.3.4 The Variability of Possible Outcomes (u)

Figure 8 shows the impact of the variability of possible outcomes (u) on the principal's optimal compensation decision (α) and on the principal's expected initial payoff (V) under rescission with a probability of unity. Panels (A) through (D) in Figure 8 are analogous to the corresponding panels in Figure 3. There is little difference between rescission and do-nothing in terms of the impact of the variability of possible outcomes, measured by u.

Panels (E) through (H) in Figure 8 show that the agent's optimal initial action (or effort level) under rescission, a^*, is less than or equal to that under do-nothing. Note that we take personal taxes into account and assume options will be exercised once stage H is reached while analyzing the case of rescission. Hence, it is not surprising to see that the agent will not give the highest level of optimal initial effort until the spread (u) between two possible outcomes is wider than under do-nothing.

6. Discussion

In this Section, we discuss the estimated agency costs if the agent is compensated only with stock options and we answer the questions raised in Section 2.

6.1 Agency Costs

We estimate the agency costs if the agent is compensated with stock options only. The agency cost is defined as the difference in expected initial payoffs between each principal-agent case with different strategy and the base case of sole-proprietorship.

Table 5 shows that the estimated agency cost is 3.16% (or 2.94%) in our one-principal-one-agent framework if the firm adopts do-nothing (or repricing) strategy with a probability of 0.2.[33] Table 5 also shows that the principal's expected initial payoff under rescission is 6.34% lower than that in the base case of sole-proprietorship. Note that, however, we assume in case of rescission that the agent exercises the options at node H and the principal rescinds the already-exercised options (or equivalently buys back α shares at a price of unity) at node HL. The decrease in the principal's expected initial payoff under rescission is mainly due to the decreased incentive at period 1 and the lost tax benefit as discussed in Section 5.3. If both repricing and rescission are considered possible, the estimated agency cost is 6.13%.

One of our contributions in this paper is that our simple model can generate a range of estimated agency costs, depending on the influence of external factors (measured by m) and the influence of the agent's action (measured by q) on the probability of reaching high-value state (H). In addition, the estimated agency costs also depend on the cost parameter for the agent's cost function, the volatility of future firm value, and the likelihood of event occurrence (repricing or rescission). An empirical test or justification for agency cost estimates in cases of repricng (or rescinding) executive stock options would be an interesting exercise.

[33] In this particular case, we set u = 0.2, the corporate tax rate, $\pi_c = 0.34$, and the probability of repricing (or rescission) is set to be equal to u. Note that the likelihood of higher firm value in next period, p(H) = $q\ m + (1 - q)\ a$. m represents the influence of external factors on p(H). The influence of the agent's action (a) is measured by q. The cost parameter for the agent's cost function, k, is set to be 0.05.

Table 5: Estimated agency costs

This table shows the estimated agency costs if the agent is compensated with stock options only. We set u = 0.2, the corporate tax rate, π_c = 0.34, and the probability of repricing (or rescission) is set to be equal to u. Note that the likelihood of higher firm value in next period, $p(H) = q\,m + (1 - q)\,a$. m represents the influence of external factors on $p(H)$. The influence of the agent's action (a) is measured by q. The cost parameter for the agent's cost function, k, is set to be 0.05.

Organization / Strategy	Mean Expected Payoff [5]	Estimated Agency Costs [6]	
Sole-proprietorship [1]	1.1789	0	+0.00%
Principal-Agent / Do-nothing [2]	1.1416	-0.0373	-3.16%
Principal-Agent / Repricing [3]	1.1443	-0.0346	-2.94%
Principal-Agent / Rescission [4]	1.1041*	-0.0747	-6.34%
Principal-Agent /Repricing+Rescission [5]	1.1066	-0.0723	-6.13%

1. We assume that the sole owner-manager has the same cost function (and cost parameter) as the agent in the principal-agent framework.

2. Do-nothing occurs when the firm commits to not rescinding the options regardless of the firm's terminal value. Note that in this case the options are in-the-money only at node HH.

3. Repricing occurs at node L; reset the exercise price to L for all α options.

4. The agent exercises the options at node H and the principal rescinds the already-exercised options (or equivalently buys back α shares at a price of unity) at node HL. To simplify the notation, we assume all payoffs are received at the terminal date t = 2 and the personal tax rate is the same as corporate tax rate.

5. The mean expected payoff is the principal's average expected initial payoff while integrating over the parameter space of $\{m, q\}$.

6. The agency cost is defined as the difference in expected initial payoffs between each principal-agent case with different strategy and the base case of sole-proprietorship.

* Note that personal taxes are considered under rescission and the options are granted at-the-money (hence the exercise price is unity). We assume that the agent's personal tax rate is the same as the corporate tax rate (π_c). Hence, $\pi_c\alpha\,(H-1)$ is the agent's tax liability as a result of exercising options at node H.

6.2 Do Executive Stock Options Encourage Risk-taking Actions?

Conventional wisdom suggests that executive stock options provide agents with incentives to take actions that increase firm risk since options increase in value with the volatility of the underlying stock. In section 5.1.4, we see that the agent's optimal initial action (or effort level), a^*, is an increasing function of the variability of possible outcomes (u) as we expect. Recall that a^* is chosen to maximize the agent's expected initial payoff. It turns out that under some conditions, a^* maximizes not only the agent's expected initial payoff but also the variance of the firm's market value at t = 1. For a less influential agent (higher q), it takes a wider spread between two possible outcomes to induce an a^* which can maximize both the expected initial payoff and the volatility of firm value at t = 1. More interestingly, our results show that the principal's expected initial payoff increases as u increases with fewer options being offered and the agent's optimal initial effort remaining constant.

Since the agent in our model is compensated solely with stock options, the above-mentioned finding suggests that under some conditions executive stock options do indeed encourage agent's risk-taking actions, even from an ex-ante viewpoint. Among others, Orphanides (1996) and Rajgopal and Shevlin (2002) provide empirical evidence on the relationship between stock option compensation and risk taking behavior. Our paper constructs an analytical framework and shows that given an option incentive contract, the agent will expect to take actions which maximize not only the agent's expected initial payoff but also the variance of the firm's market value in the next period as long as enough up-side reward is provided.

6.3 Is Repricing Still an Optimal Solution to Underwater Options after December 1998?

Repricing was the most common solution to underwater options until July 2000. Taking effect in summer 2000 and retroactive to December 15, 1998, the accounting rules imposed by the FASB forced companies to take a variable charge to earnings for repriced options. According to the Investor Responsibility Research Center (IRRC),[34] reported incidences of traditional repricing decrease from 167 in 1999 to 59 in 2000 as a result of the accounting rule changes.

In Subsection 5.2.1, we show that the principal is worse off in terms of expected initial payoffs under repricing than under do-nothing especially when k is high or the influence of external factors (represented by m) is high. However, Table 6 indicates that the principal, on average, has a higher expected initial payoff under repricing, although the difference is not statistically significant. These results suggest that repricing seemingly restore incentive-alignment for underwater options for high-cost agents. This result is consistent with AJS, which is a special case of ours when $q = 0$. On the other

[34] IRRC is a source of independent research on corporate governance, proxy voting and corporate responsibility issues.

hand, for low-cost agents, the principal will offer more options initially and have a lower expected initial payoff if repricing is anticipated with certainty ($\pi = 1$).

In other words, some of our results are consistent with those in AJS but we claim that repricing is not different, on average, from do-nothing in terms of the principal's expected initial payoffs. Table 6 shows average equilibrium payoffs under both do-nothing and repricing strategies. The averages are taken by integrating variables of interest over the parameter space, ($\{k, u, m, q\}$). The results in Table 6 indicate that the principal's expected initial payoff (V) is slightly higher under repricing than under do-nothing, but the difference is not statistically significant. Repricing, however, definitely loses its ex-ante dominance over do-nothing strategy as claimed by AJS after we incorporate dilution effects and the tax effects of new accounting rules associated with repricing.[35]

[35] At this point, we are not able to draw strong conclusions about the optimality of traditional repricing because of the limitation of our two-period model. Specifically, our model is not rich enough to capture fully the economic impact of new accounting rules with a marking-to-market feature. Nonetheless, we show that the combined impact of dilution effects and tax effects on the ex-ante contracting decision is economically significant.

Table 6: Do-nothing vs. Repricing

This table describes average equilibrium payoffs under both do-nothing and repricing strategies. The averages are taken by integrating variables of interest over the parameter space, ($\{k$, u, m, $q\}$). π is the probability of repricing at node L. a^*_0 is the agent's optimal initial action, on average, and a^*_1 is the weighted average optimal action at period 1. Standard errors are in the parentheses. Note that personal taxes are ignored and that options are granted at-the-money.

Variables	Do-nothing[1]	Repricing[2]			
	($\pi = 0$)	$\pi = 1$	$\pi = 0.5$	$\pi = 0.2$	$\pi = u$
V	**1.4258**	**1.4426**	1.4360	1.4302	**1.4405**
	(0.8309)	(0.8074)	(0.8189)	(0.8262)	(0.8138)
U	0.1245	0.1467	0.1334	0.1271	0.1353
	(0.1765)	(0.1841)	(0.1796)	(0.1767)	(0.1825)
α	**0.5995**	**0.6583**	0.6386	0.6213	0.6383
	(0.4138)	(0.4030)	(0.4051)	(0.4086)	(0.4057)
a^*_0	**0.5064**	**0.4755**	0.4950	0.5025	**0.4971**
	(0.4445)	(0.4410)	(0.4432)	(0.4442)	(0.4422)
a^*_1	**0.4444**	**0.5011**	0.4722	0.4554	**0.4684**
	(0.4071)	(0.4019)	(0.4018)	(0.4046)	(0.4068)
a^*_h	0.6198	0.6203	0.6205	0.6199	0.6202
	(0.4436)	(0.4426)	(0.4426)	(0.4432)	(0.4430)
a^*_l	**0.0000**	**0.2006**	0.0963	0.0379	0.0922
	(0.0000)	(0.2035)	(0.0946)	(0.0368)	(0.0879)

[1] Do-nothing occurs when the firm commits to not repricing the options regardless of the firm's terminal value. Note that in this case the options are in-the-money only at node HH.

[2] Repricing occurs at node L; reset the exercise price to L for all α options.

6.4 Do Accounting Charges Matter?

Yes. We compute average equilibrium payoffs as we do in Table 6 under both do-nothing and repricing strategies but without incorporating the dilution effect and the tax effect associated with the new accounting rules. We use superscripts A and NA to denote accounting and no-accounting respectively. The following table shows that the principal's expected initial payoff under do-nothing (repricing) is overestimated by 24.27% (22.58%) if the dilution effect and the tax effect are not included in payoff structure. On the other hand, the initial option grant under do-nothing (repricing) is underestimated by 3.75% (11.70%). According to these results, we claim that the combined impact of the dilution effect and the tax effect on the principal's expected initial payoff and on the decision of initial option contract is economically significant.

Variables	Do-nothing	Repricing
	$(\pi = 0)$	$\pi = 1$
V^{A}	1.4258	1.4426
α^{A}	0.5995	0.6583
V^{NA}	1.7718	1.7683
α^{NA}	0.5770	0.5812

6.5 Can We Justify the Occurrence of Rescission?

Yes. The principal anticipates the tax benefits and positive cash flows resulting from option exercises at node H if no rescission occurs at node HL. Therefore, the principal will grant as many options as he or she can offer at the initial stage ($\alpha^{N} \approx 1$). As a result, we see little change on the principal's initial incentive contract decision ($\alpha^{R\text{-}N} \approx 0$), a higher level of effort from the agent at the initial stage (higher a^*), and the negative feedback effect at stage H (slightly lower a^*_h). Overall, Table 7 shows that both the principal and the agent will be better off under a sure rescission policy in terms of expected initial payoffs than under do-nothing, although the principal is statistically indifferent.

The above-mentioned results are intuitively consistent. First, rescission should have no influence on the decision to grant an initial incentive contract since rescission, a tax-motivated strategy, is not designed to provide or align incentives. Second, once the agent exercises options at node H, there is no incentive-alignment issue between the principal and the agent. As long as rescission is not guaranteed at the initial stage, the agent has sufficient incentives to avoid reaching stage HL because of the tax liability resulting from exercising options at node H. This means that the negative feedback effect can be mitigated by the uncertainty of rescission.

Table 7 describes average equilibrium payoffs under both do-nothing and rescission strategies. The averages are taken by integrating variables of interest over the parameter space, ($\{k, u, m, q\}$). We show that in Table 7 the agent under a sure rescission policy ($\pi = 1$) will offer a higher level of effort (a^*_0 increases from 0.3664 to 0.4065) at the initial stage. Once stage H is reached, the agent will give less effort (a^*_h decreases from 0.5887 to 0.5400) to reflect the negative feedback effect resulting from the anticipation of rescission at node HL. As expected, the agent is better off under a sure rescission policy in terms of expected initial payoffs (U increases by 14%, from 0.0712 under do-nothing to 0.0812 under a sure rescission policy).

Interestingly, the principal is also better off in terms of expected initial payoffs under rescission than under do-nothing (V increases by 4%, from 1.2918 under do-nothing to 1.3033 under a sure rescission policy). Section 5.3 also mentions another interesting policy implication: If there is a sure rescission policy in place, the principal will be better off under rescission if he or she hires a high-cost agent whose action is the sole factor in determining the likelihood of being in the high-value state.

6.6 Is this a "Heads, I Win; Tails, You Lose" Game?

The question here is if executives anticipate that both rescission and repricing may take place in the future, whether and how the firm and executives respond from an ex-ante viewpoint. More precisely, we examine if the agent will be better off under the combined strategy than under the rescission strategy alone ("Heads, I Win") and if the principal will be worse off under the combined strategy than under the repricing strategy alone ("Tails, You Lose").

Our results show in Table 8 that in order to enhance a positive continuation effect once node L is reached the principal will offer more options at the initial stage than he/she will if only rescission is considered possible. However, the agent will choose a lower level of initial effort than he/she will in case of rescission or repricing to reflect the negative feedback effects from both ends. The weighted average optimal level of effort at period 1 (a^*_1) under the combined strategy is in-between the ones under repricing and rescission alone. Consequently, from an ex-ante viewpoint, the agent will have a higher expected initial payoff (0.1036) than under rescission (0.0812). The 27.57% increase in the agent's expected initial payoff mainly results from accepting more initial options. On the other hand, the principal will have a lower expected initial payoff (1.3158) than under repricing (1.4426) because of the negative feedback effects from both ends. According to these results, we will argue that it is a "High (H), the agent wins; Low (L), the principal loses" game.

Table 7: Do-nothing vs. Rescission

This table describes average equilibrium payoffs under both do-nothing and rescission strategies. The averages are taken by integrating variables of interest over the parameter space, ($\{k$, u, m, $q\}$). π is the probability of rescission at node HL. a^{*}_{0} is the agent's optimal initial action, on average, and a^{*}_{1} is the weighted average optimal action at period 1. Standard errors are in the parentheses. Unlike repricing, Rescission is analyzed while considering the agent's personal taxes.

Variables	Do-nothing[1]	Rescission[2]			
	($\pi = 0$)	$\pi = 1$	$\pi = 0.5$	$\pi = 0.2$	$\pi = u$
V	**1.2918**	**1.3033**	1.2952	1.2925	1.2989
	(0.7957)	(0.7880)	(0.7932)	(0.7951)	(0.7912)
U	0.0712	**0.0812**	0.0749	0.0724	0.0779
	(0.1064)	(0.1135)	(0.1087)	(0.1071)	(0.1124)
α	0.6722	0.6313	0.6532	0.6643	0.6554
	(0.4022)	(0.4221)	(0.4126)	(0.4068)	(0.4119)
a^{*}_{0}	**0.3664**	**0.4065**	0.3797	0.3703	0.3881
	(0.4241)	(0.4255)	(0.4253)	(0.4245)	(0.4285)
a^{*}_{1}	0.3644	0.3637	0.3629	0.3634	0.3651
	(0.3919)	(0.3948)	(0.3937)	(0.3927)	(0.3940)
a^{*}_{h}	**0.5887**	**0.5400**	0.5668	0.5803	0.5679
	(0.4461)	(0.4426)	(0.4458)	(0.4460)	(0.4445)
a^{*}_{l}	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

1. Do-nothing occurs when the firm commits to not rescinding the options regardless of the firm's terminal value. Note that in this case the agent takes personal taxes into account and the options are in-the-money only at node HH.

2. The agent exercises the options at node H and the principal rescinds the already-exercised options (or equivalently buys back α shares at a price of unity) at node HL. To simplify the notation, we assume that all payoffs are received at the terminal date t = 2 and the personal tax rate is the same as corporate tax rate.

Table 8: Do-nothing vs. Repricing and Rescission Combined

This table describes average equilibrium payoffs under both do-nothing and combined (repricing and rescission) strategies. The averages are taken by integrating variables of interest over the parameter space, ($\{k$, u, m, $q\}$). π is the probability of rescission at node HL. a^*_0 is the agent's optimal initial action, on average, and a^*_1 is the weighted average optimal action at period 1. Standard errors are in the parentheses. Unlike repricing, Rescission is analyzed while considering the agent's personal taxes.

Variables	Do-nothing[1]	Repricing + Rescission[2]			
	($\pi = 0$)	**$\pi = 1$**	$\pi = 0.5$	$\pi = 0.2$	$\pi = u$
V	1.2918	**1.3158**	1.3070	1.2986	1.3138
	(0.7957)	(0.7568)	(0.7750)	(0.7873)	(0.7681)
U	0.0712	[redacted]	0.0831	0.0751	0.0883
	(0.1064)	(0.1202)	(0.1103)	(0.1075)	(0.1178)
α	0.6722	**0.6831**	0.6793	0.6781	0.6799
	(0.4022)	(0.4076)	(0.4071)	(0.4046)	(0.4061)
a^*_0	0.3664	**0.3535**	0.3611	0.3647	0.3717
	(0.4241)	(0.4109)	(0.4198)	(0.4227)	(0.4214)
a^*_1	0.3644	**0.4446**	0.4044	0.3807	0.4002
	(0.3919)	(0.3924)	(0.3862)	(0.3885)	(0.3931)
a^*_h	0.5887	0.5421	0.5684	0.5811	0.5695
	(0.4461)	(0.4400)	(0.4445)	(0.4455)	(0.4431)
a^*_l	0.0000	0.2332	0.1159	0.0461	0.1147
	(0.0000)	(0.2479)	(0.1224)	(0.0480)	(0.1192)

1. Do-nothing occurs when the firm commits to not repricing and rescinding the options regardless of the firm's terminal value. Note that in the case of rescission the agent takes personal taxes into account and the options are in-the-money only at node HH.

2. Repricing will occur, if any, at node L; reset the exercise price to L for all α options. The agent exercises the options at node H and the principal rescinds the already-exercised options (or equivalently buys back α shares at a price of unity) at node HL. To simplify the notation, we assume that all payoffs are received at the terminal date t = 2 and the personal tax rate is the same as corporate tax rate.

7. Conclusion

We extend the model of AJS to examine the ex-ante optimality of repricing and rescission of executive stock options (ESOs) while considering dilution effects and the tax effects of new accounting rules associated with repricing and rescission. At the beginning of each period, the agent chooses an optimal level of effort (or action) to maximize his/her expected end-of-period payoff. Anticipating the agent's action, on the other hand, the principal selects an initial option-based incentive contract to maximize his/her expected initial payoff in a situation where repricing and/or rescission of the agent's stock options are possible.

Since July 2000, the companies that used to reprice underwater options or will likely do so have chosen one of the repricing alternatives[36] over the traditional repricing to avoid the accounting charges. However, the possible optimality of traditional repricing after considering the economic impact of changing accounting rules has not been addressed in an ex-ante contracting setting. Our paper serves that purpose.

Repricing loses its ex-ante dominance over the do-nothing strategy, as claimed by AJS, after we incorporate dilution effects and the tax effects of new accounting rules associated with repricing. On average, repricing is indifferent from do-nothing in terms of the principal's expected initial payoffs. Table 6 shows the trade-off between the (positive) continuation effect and the (negative) feedback effect resulting from repricing. For example, the optimal level of effort chosen by the agent at the initial stage (a^*_0) is lower under repricing than under do-nothing and decreases as the probability of repricing (π) increases. This (negative) feedback effect is offset by the (positive) continuation effect, indicated by (a^*_1). However, stronger conclusions about the optimality of traditional repricing cannot be drawn until the economic impact of new accounting rules with a marking-to-market feature is fully captured. Nonetheless, we show that the combined impact of dilution effects and tax effects on ex-ante contracting decision is economically significant.

We also suggest that under some conditions, executive stock options do indeed encourage the agent's risk-taking actions, even from an ex-ante viewpoint. Although an increasing body of literature empirically tests this hypothesis, our paper sheds some light on this issue from an analytical ex-ante contracting viewpoint. We show that given an option incentive contract, the agent, under some conditions, will expect to take actions which maximize not only the agent's expected initial payoff but also the variance of the firm's market value in the subsequent period. This result is consistent with the intuitive understanding of the convex payoff structure of executive stock options. With that said, we also claim that the agent may not take the riskier actions induced by his/her option-based compensation if the dilution effect and the positive continuation effect resulting from repricing are taken into account.

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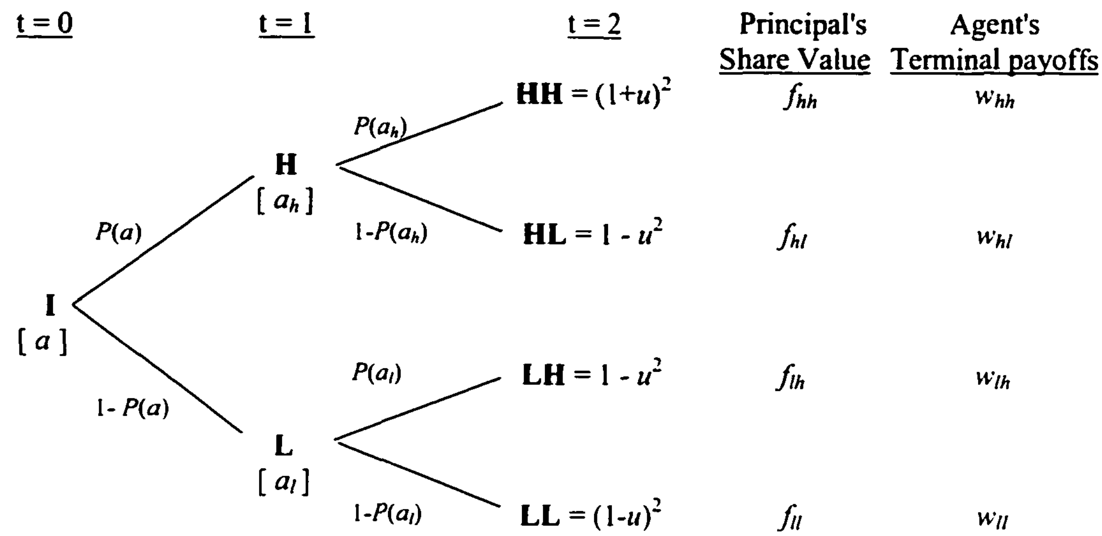
[36] See Yang and Carleton (2002) for details about repricing alternatives.

Finally, rescission may be the least favorable practice from the principal's ex-post viewpoint. The principal, however, will be almost always better off in terms of expected initial payoffs under rescission than under the do-nothing policy if he or she takes the tax benefit and cash flows resulting from the option exercises at node H into account and designs the initial option contract accordingly. Put differently, the presumed negative effect on the agent's incentive at period 1 may be outweighed by the deliberate initial contract and the potential cash inflow and tax benefit resulting from the agent's exercise of existing options at node H. Hence, rescission may be, from an ex-post viewpoint, a business practice in which firms bail out the executives at shareholders' expense. Rescission can still be an important and value-enhancing strategy from an ex-ante standpoint.

Figure 1

A two-period binomial model and distribution of terminal cash flows.



where $P(a) = q\ m + (1\text{-}q)\ a$

Parameters/ Variables	Range	Descriptions
α	(0, 1]	The option contact offered by the principal at node I
a	[0,1]	The action (or effort level) taken by the agent at node I
a_h	[0,1]	The action (or effort level) taken by the agent at node H
a_l	[0,1]	The action (or effort level) taken by the agent at node L
$P(a)$	[0,1]	The probability of reaching node H
q	[0,1]	The extent to which the agent's action may influence $P(a)$
m	[0,1]	The influence of external factors on $P(a)$.
u	(0,1)	The variability of firm value at t = 1 (H = 1 + u, L = 1 - u)
π	[0,1]	The probability of underwater options being repriced at node L

Figure 2: Do-nothing

Sensitivity of Cost (k), Market (m), and Control (q) Variables

Under the do-nothing strategy, this figure shows the influence of the parameters of interest on the principal's expected payoff (V) in equilibrium and on the optimal initial option grant (alpha). The base parameters are fixed at u = 0.2, and the corporate tax rate, π_c = 0.34. Note that the likelihood of higher firm value in next period, p(H) = q m + (1-q) a. m represents the influence of external factors on p(H). The influence of the agent's action (a) is measured by q. k is the cost parameter for the agent's cost function.

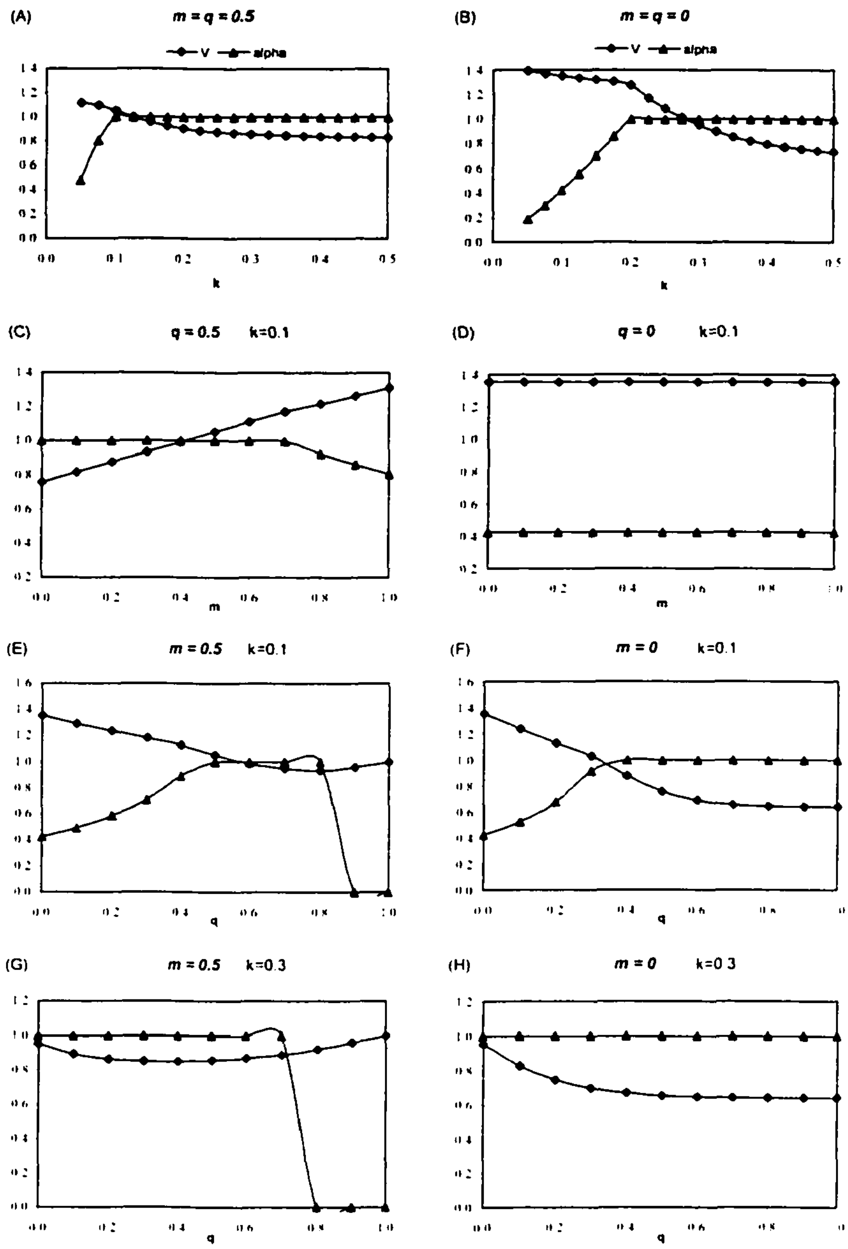
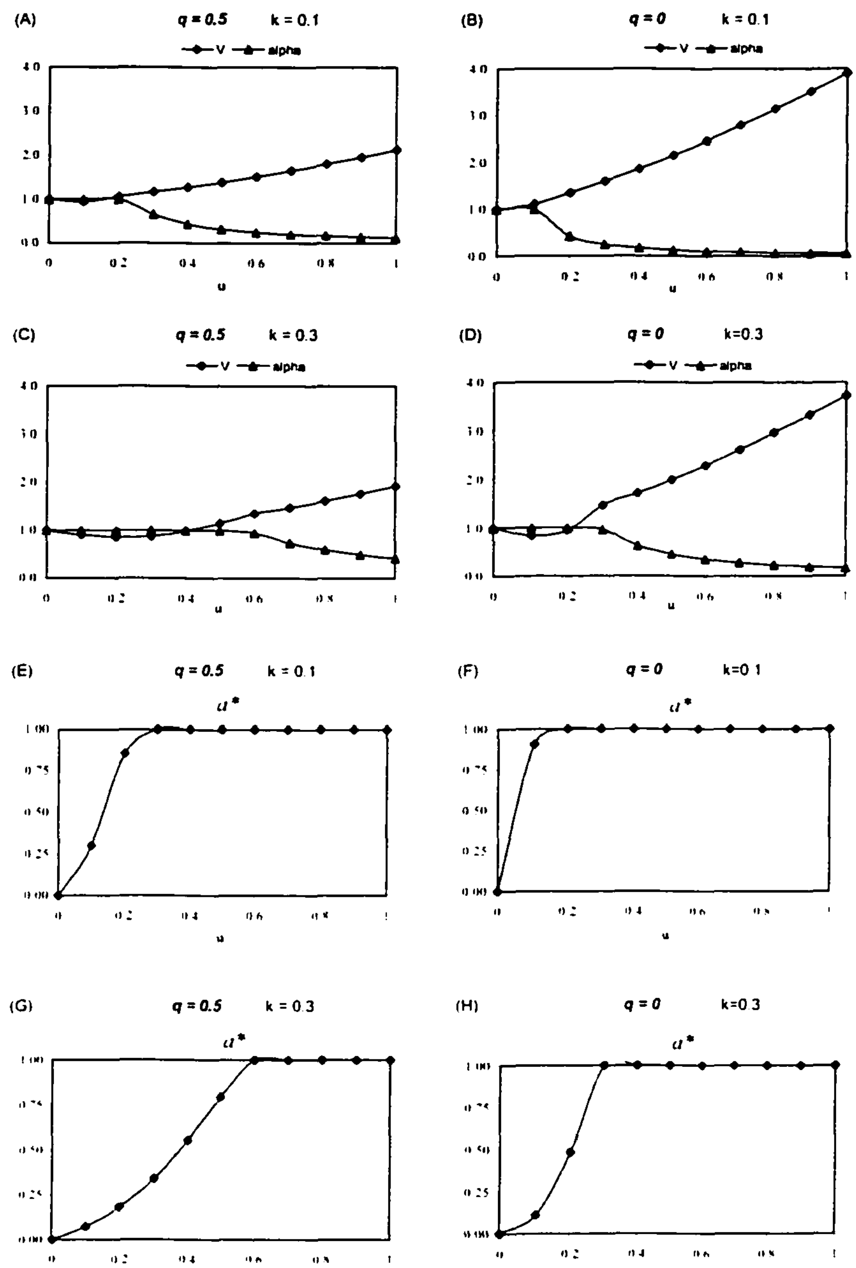


Figure 3: Do-nothing

Sensitivity of the Variability of Possible Outcomes (u)

Under the do-nothing strategy, this figure shows the influence of return volatility (u) on the principal's expected initial payoff (V) in equilibrium and on the optimal option grant (alpha). Note that H = 1+ u, and L = 1 - u and we set the corporate tax rate, $\pi_c = 0.34$. The likelihood of higher firm value in next period, $p(H) = q\,m + (1\text{-}q)\,a$. m represents the influence of external factors on p(H). The influence of the agent's action (a) is measured by q. k is the cost parameter for the agent's cost function. We set m = 0.5, unless indicated otherwise. a* is the optimal initial action (or effort level) chosen by the agent.



<u>Figure 4:</u> Repricing with a Probability of Unity

Sensitivity of Cost (k), Market (m), and Control (q) Variables

We use the letters N and R to denote no-repricing and repricing, respectively. When repricing occurs at node L with a probability equal to one, this figure shows the influence of the parameters of interest on the difference of the principal's expected payoff [V(R-N)] in equilibrium and on the difference of optimal initial option grant [alpha(R-N)]. We set u = 0.2 and the corporate tax rate, pc = 0.34. Note that the likelihood of higher firm value in next period, p(H) = q m + (1-q) a. m represents the influence of external factors on p(H). The influence of the agent's action (a) is measured by q. k is the cost parameter for the agent's cost function.

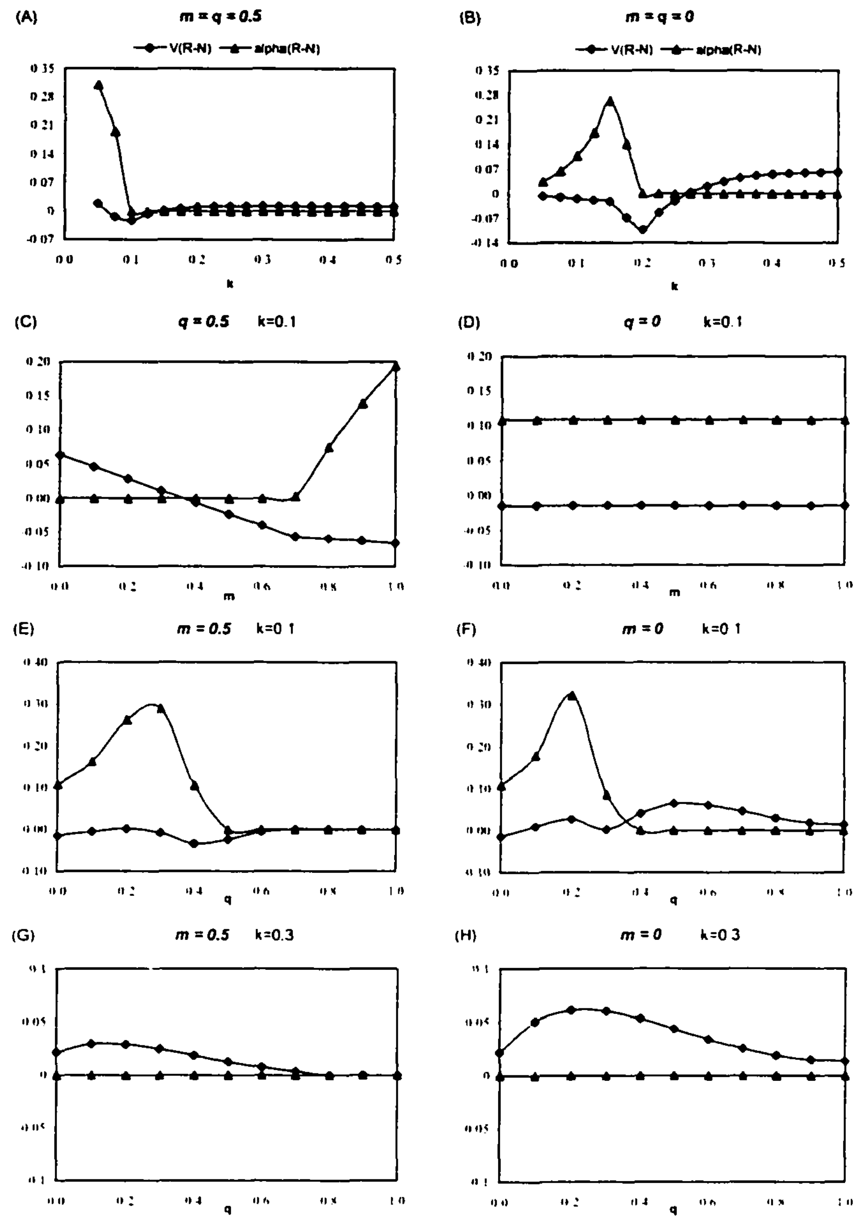


Figure 5: Repricing with a Probability of Unity
Sensitivity of the Variability of Possible Outcomes (u)

Under repricing with a probability of unity, this figure shows the influence of return volatility (u) on the principal's expected initial payoff (V) in equilibrium and on the optimal option grant (alpha). Note that H = 1+ u, and L = 1 - u and we set the corporate tax rate, $\pi_c = 0.34$. The likelihood of higher firm value in next period, p(H) = $q\ m$ + (1-q) a. m represents the influence of external factors on p(H). The influence of the agent's action (a) is measured by q. k is the cost parameter for the agent's cost function. We set m = 0.5, unless indicated otherwise. a* is the optimal initial action (or effort level) chosen by the agent.

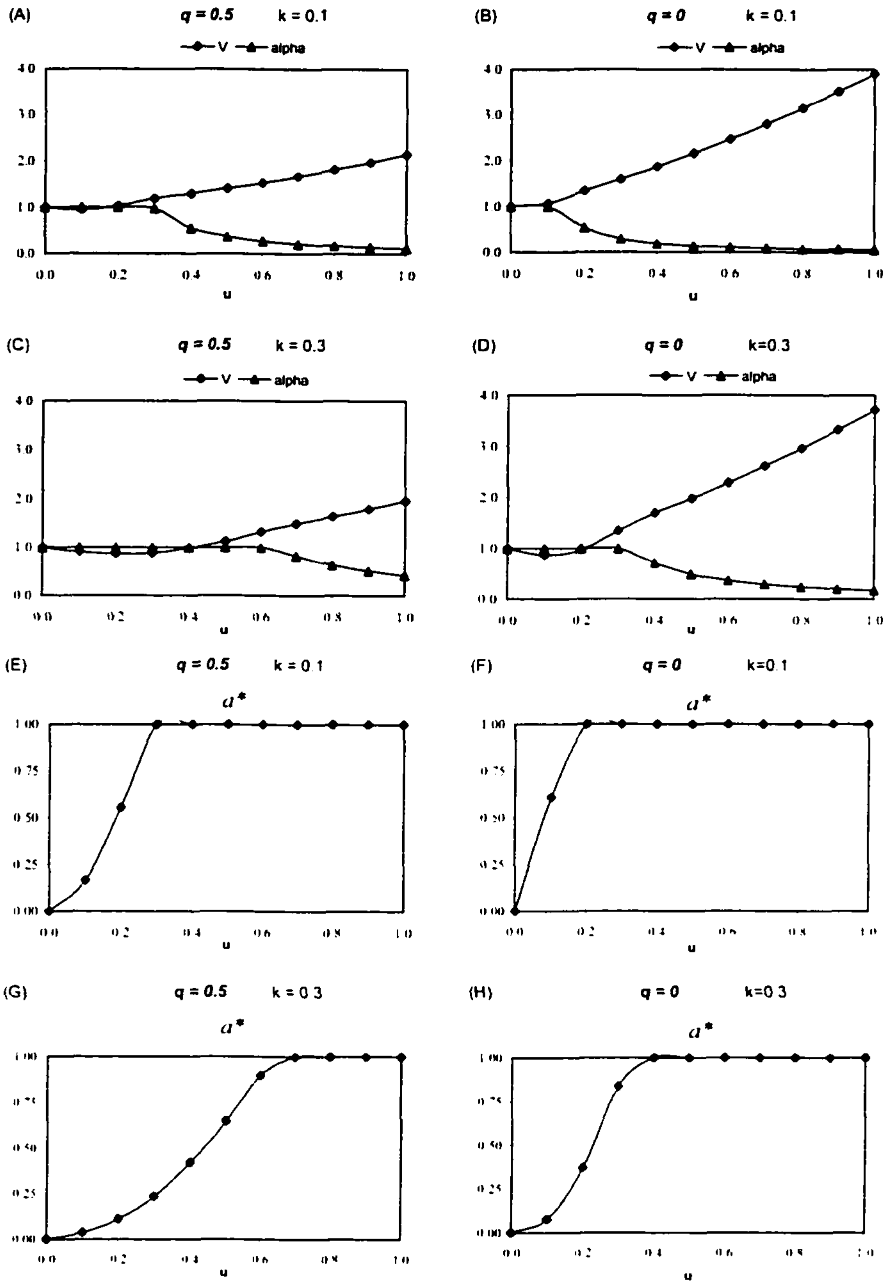


Figure 6: Repricing with a Probability of *u* (=0.2)

Sensitivity of Cost (k), Market (m), and Control (q) Variables

We use the letters N and R to denote no-repricing and repricing, respectively. When repricing occurs at node L with a probability equal to u, this figure shows the influence of the parameters of interest on the difference of the principal's expected payoff [V(R-N)] in equilibrium and on the difference of optimal initial option grant [alpha(R-N)]. We set u = 0.2 and the corporate tax rate, π_c = 0.34. Note that the likelihood of higher firm value in next period, $p(H) = q\ m + (1\text{-}q)\ a$. m represents the influence of external factors on p(H). The influence of the agent's action (a) is measured by q. k is the cost parameter for the agent's cost function.

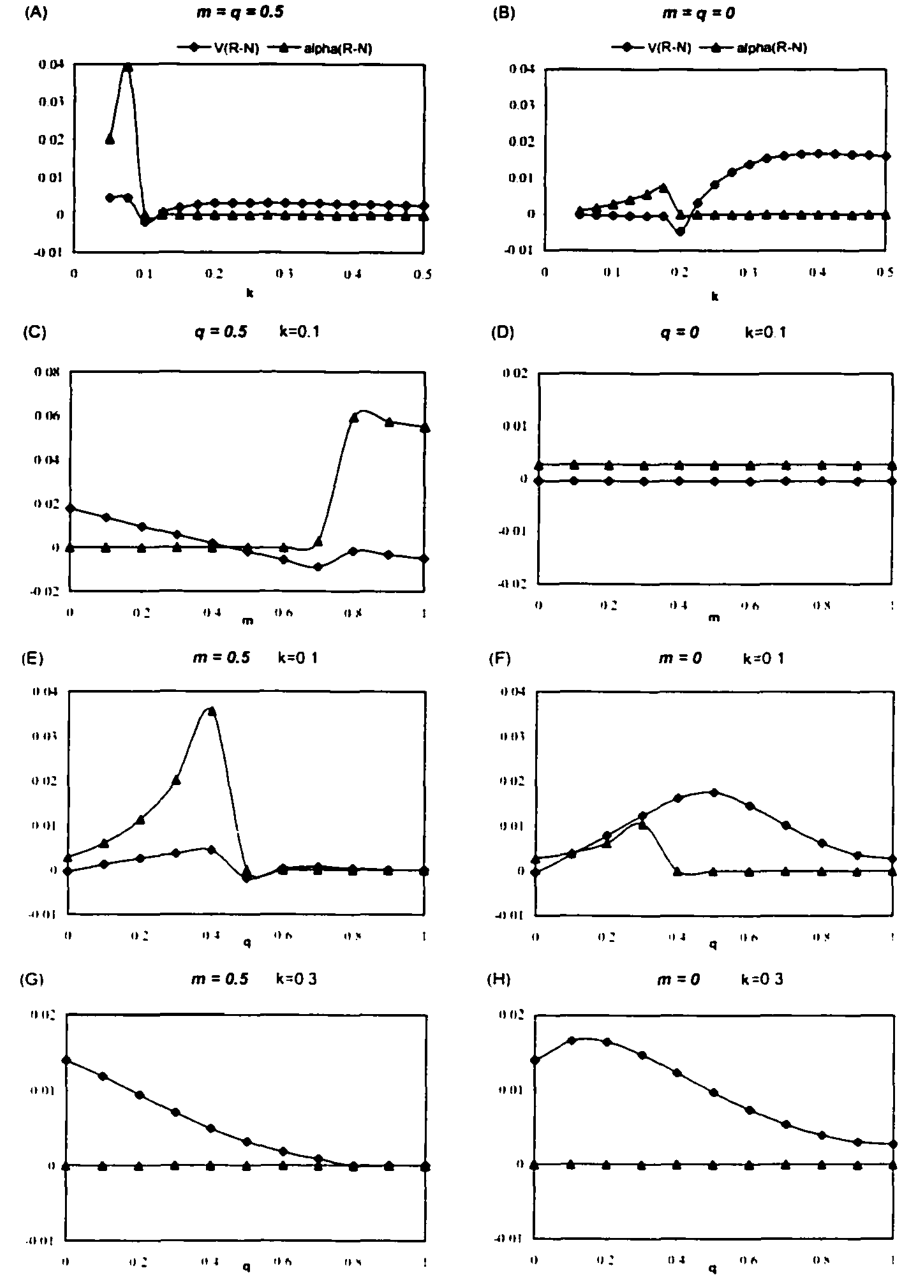


Figure 7: Rescission with a Probability of Unity
Sensitivity of Cost (k), Market (m), and Control (q) Variables

We use the letters N and R to denote do-nothing and rescission, respectively. When rescission occurs at node HL with a probability equal to one, this figure shows the influence of the parameters of interest on the difference of the principal's expected payoff [V(R-N)] in equilibrium and on the difference of optimal initial option grant [alpha(R-N)]. We set u = 0.2 and the corporate tax rate, π_c = 0.34. Note that the likelihood of higher firm value in next period, $p(H) = q\ m + (1-q)\ a$. m represents the influence of external factors on p(H). The influence of the agent's action (a) is measured by q. k is the cost parameter for the agent's cost function.

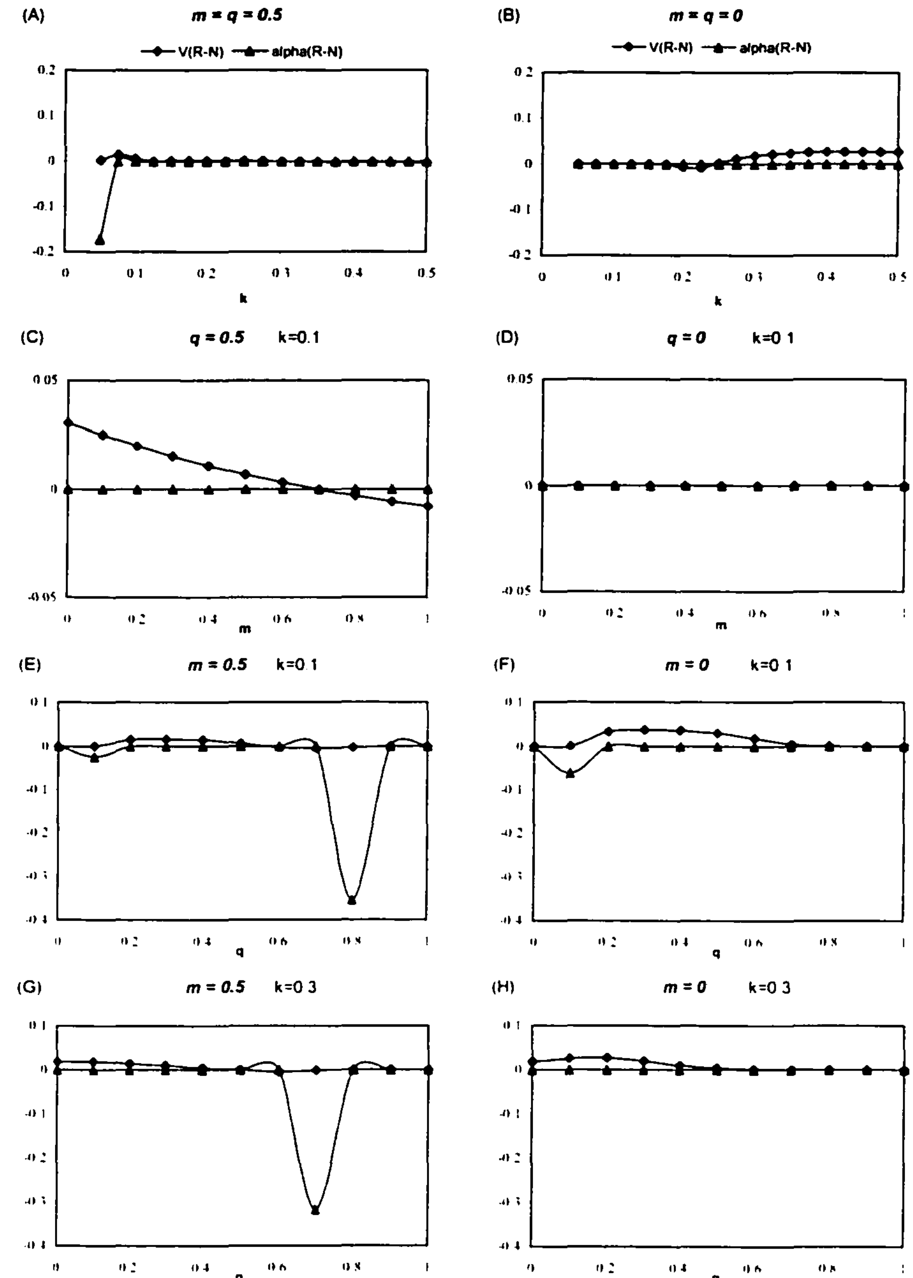


Figure 8: Rescission with a Probability of Unity

Sensitivity of the Variability of Possible Outcomes (u)

Under rescission with a probability of unity, this figure shows the influence of return volatility (u) on the principal's expected initial payoff (V) in equilibrium and on the optimal option grant (alpha). Note that H=1+ u, and L=1 - u and we set the corporate tax rate, π_c = 0.34. The likelihood of higher firm value in next period, p(H) = $q\,m + (1\text{-}q)\,a$. m represents the influence of external factors on p(H). The influence of the agent's action (a) is measured by q. k is the cost parameter for the agent's cost function. We set m = **0.5**, unless indicated otherwise. a^* is the optimal initial action (or effort level) chosen by the agent.

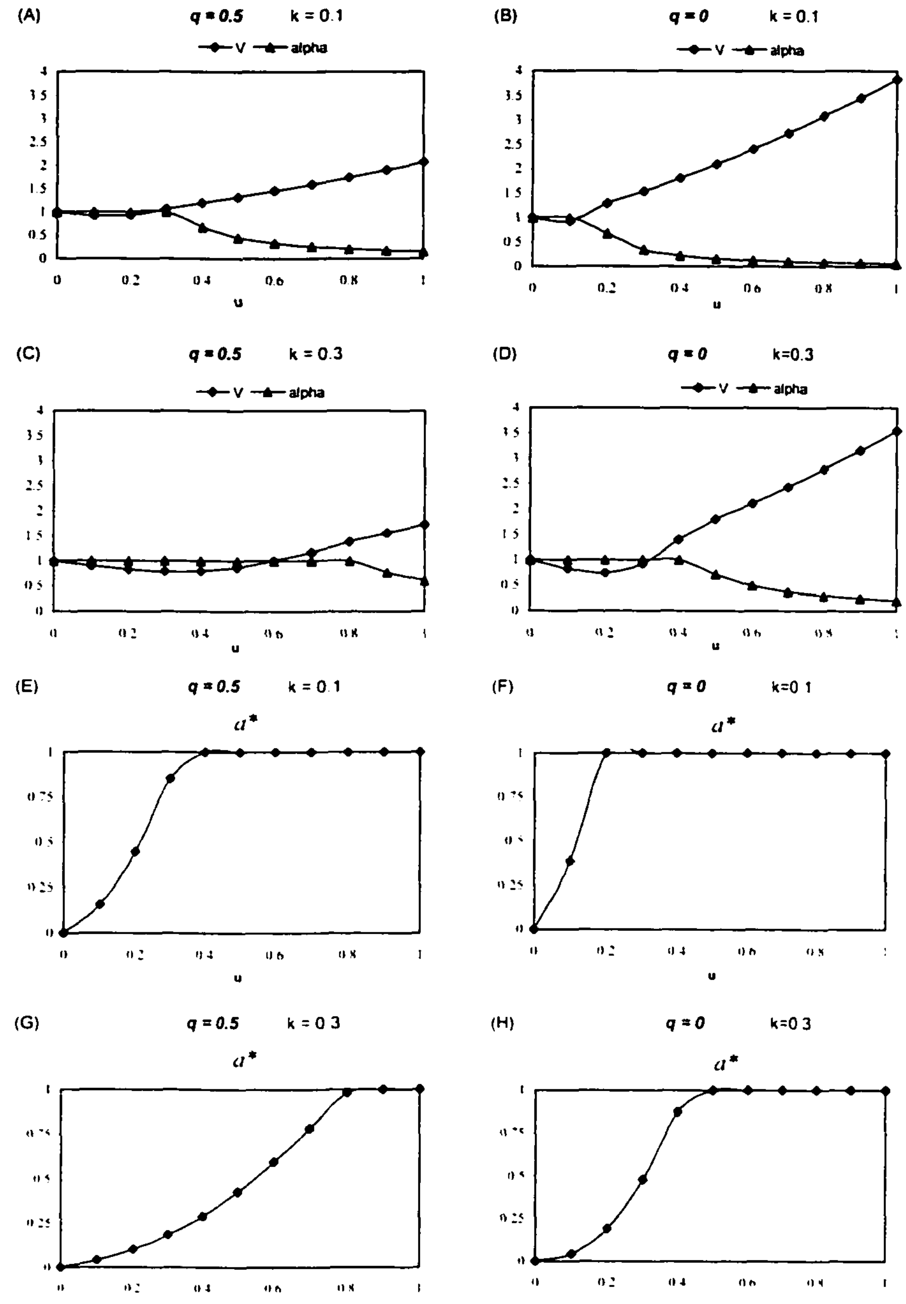
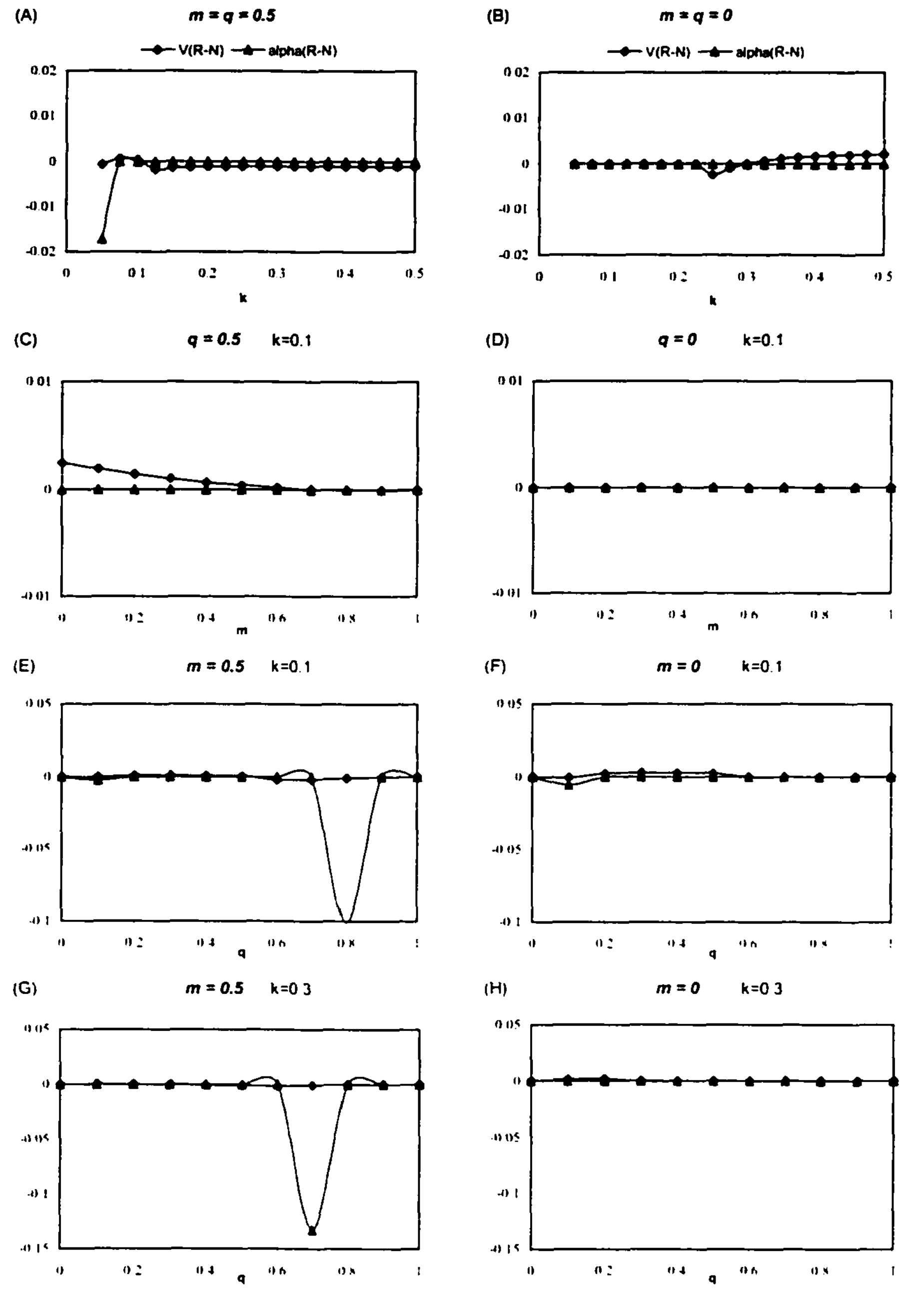


Figure 9: Rescission with a Probability of u (=0.2)

Sensitivity of Cost (k), Market (m), and Control (q) Variables

We use the letters N and R to denote do-nothing and rescission, respectively. When rescission occurs at node HL with a probability equal to u, this figure shows the influence of the parameters of interest on the difference of the principal's expected payoff [V(R-N)] in equilibrium and on the difference of optimal initial option grant [alpha(R-N)]. We set u = 0.2 and the corporate tax rate, π_c = 0.34. Note that the likelihood of higher firm value in next period, $p(H) = q\ m + (1\text{-}q)\ a$. m represents the influence of external factors on p(H). The influence of the agent's action (a) is measured by q. k is the cost parameter for the agent's cost function.



Chapter 2:

Repricing Alternatives, Optimal Repricing Policy, and Early Exercise of Executive Stock Options

Abstract

Traditional executive stock option repricing practices have become obsolete since new accounting rules took effect in July 2000. To avoid associated variable accounting charges that cause uncertainty in future reported earnings, companies have tried several repricing alternatives as solutions to rescuing underwater options. In our three-period utility-maximizing model, dynamic programming is used to not only justify the occurrence of some repricing alternatives but also quantify the impact of the marking-to-market feature imbedded in the new accounting rules. In addition, we derive optimal repricing policies, from an ex-ante viewpoint, which specify how deeply the options are under water before repricing takes place.

Executive Summary

In practice, traditional repricing (TR) has become obsolete since new accounting rules took effect in July 2000. To avoid associated variable accounting charges that cause uncertainty in future reported earnings, companies have tried several repricing alternatives as solutions to rescuing underwater options. We use a three-period utility-maximizing model to not only justify the occurrence of some repricing alternatives but also quantify the impact of the marking-to-market feature imbedded in the new accounting rules. In addition, we derive optimal repricing policies, from an ex-ante viewpoint, which specify how deeply the options are under water before repricing takes place.

We compare two repricing alternatives, delayed repricing (DR) and advanced repricing (AR), with TR in terms of the principal's expected payoff at the initial stage. We find that, from an ex-ante standpoint, AR as an alternative almost always benefits the agent at the principal's expense because of early exercise, dilution effect, and less effort (from the agent) at the initial stage, resulting from the agent's anticipation of AR as a protection. We also show that TR actually offers most incentive for the agent in terms of the increase in the agent's wealth per dollar increase in the principal's payoff while comparing with two repricing alternatives under consideration. Hence, choosing either DR or AR to avoid the accounting charges associated with TR will be a suboptimal choice for the principal if providing incentive is the main reason to reprice underwater options. Earnings management alone does not justify the occurrence of AR from public shareholders' viewpoint.

Finally, we derive ex-ante optimal repricing policies to specify how deeply the options are under water before repricing takes place. These optimal repricing policies can be used for designing an option-based compensation contract with a predetermined triggering point of repricing. Our simulation results under each optimal repricing policy provide predictions about the conditions under which repricing is more likely to occur, such as the agent's risk preference and the amount of initial option grant. The optimal repricing policy also provides predictions about market conditions that suggest how much the stock price actually decreases when repricing is triggered under each policy. To verify these predictions will be an interesting empirical exercise.

1. Introduction

Repricing options is a process of canceling existing outstanding options and reissuing new options at a lower strike price. Traditional repricings simply lower the exercise prices of existing options. Repricing was the most common solution to underwater options until July 2000. Taking effect in summer 2000 and retroactive to December 15, 1998, the accounting rules imposed by the Financial Accounting Standards Board (FASB) forced companies to take a variable charge to earnings for repriced options. These variable charges, as opposed to one-time fixed costs, require companies to mark-to-market all repriced options in each quarterly earnings report.

The recent changes in accounting rules associated with repriced employee stock options (ESOs) have made traditional repricing obsolete. According to the Investor Responsibility Research Center (IRRC),[37] reported incidences of traditional repricing decreased from 167 in 1999 to 59 in 2000 as a result of the accounting rule changes. With all those rule changes in mind, companies have tried many repricing alternatives to avoid associated variable accounting costs.[38]

Variable accounting costs can also be avoided if a company cancels existing options (or settles for cash) and grants a replacement award at a lower exercise price

[37] IRRC is a source of independent research on corporate governance, proxy voting and corporate responsibility issues.
[38] See Table 1 for a list of repricing alternatives.

more than six months before or after the cancellation (or settlement).[39] The question is who (shareholders or employees) should or will be willing to bear the risks associated with either strategy. Although this question remains debatable from an ex-post viewpoint, we analyze the optimality of these repricing strategies for the principal (or public shareholders), quantify the incentives provided by each repricing alternative for the agent (or executives/employees), and propose an optimal repricing policy from an ex-ante contracting standpoint.

The first repricing alternative introduced here is called "delayed repricing" or the "6&1" method. Under this strategy, a company grants a replacement award six months and one day after the cancellation of underwater options to avoid variable accounting charges. The motivation of employees during the 6-month period might be quite different from that of the company's public shareholders. Employees might hope that the stock price remains unchanged or, even better, drops by the end of the six-month period in order to receive a lower strike price on new options. On the other hand, it may be unrealistic to expect that such a plan will drive employees to underperform in order to keep the stock price down just long enough for new options awards to take effect.

With "delayed repricing," employees also face the decision of whether to trade in their old options for new ones six months and one day later, given a volatile market. Since they are literally out of the market option-wise for six months, employees might

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[39] A special rule applies if the replaced options were previously repriced, according to the FASB's

forgo all of the upside on the stock just because they were out of the market at the wrong period of time. Meanwhile, there is no incentive for employees to try to increase share values during the 6-month period.

Another alternative, called "advanced repricing," is to grant new options at the market price up front in return for surrender of old grants by the employee after six months and one day. An immediate concern to shareholders is the potential double dilution during the 6-month period if the stock market rebounds high enough to allow employees to cash in from their used-to-be underwater options.

Another key task facing corporations is to devise innovative incentive contracts to retain as well as attract key talent while considering volatility of the stock market inevitable. The "truncated option" serves that purpose. The truncated option is an ESO with a repricing feature imbedded in the contract *ex ante*. Hence, the truncated options are subject to the variable award accounting to begin with. However, the exercise period of truncated options will be automatically reduced and the options expire without cancellation if the stock price falls below a predetermined level. On one hand, employers can salvage underwater options to boost employees' morale on an *ex-ante* basis. On the other hand, shareholders may question why they even reward employees' poor performance by including a repricing feature in the options contracts as well as having variable accounting charges from the beginning.

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interpretation No. 44.

The main focus of this paper is to assess the ex-ante optimality of the repricing strategies mentioned above in terms of protecting shareholders' interests while facing the challenge of invigorating executive morale deflated as a result of plunging stock prices. Specifically, we use no repricing (hereafter NR) as a benchmark strategy to compare with traditional repricing (TR), delayed repricing (DR), and advanced repricing (AR). In doing so, we allow the employees' expected terminal wealth (therefore the shareholders' as well) to be contingent upon the path, early exercise strategy, as well as the chosen repricing strategy by the firm.

Following Yang and Carleton (2002), we propose an optimal repricing policy which specifies how deeply the options are under water before repricing takes place. Although Brenner, Sundaram and Yermack (2000) report that repricing involves a 40% drop, on average, in the strike price, there has been no research on investigating if there exists, from an ex-ante viewpoint, an optimal degree to which existing options are under water in triggering repricings. Our paper serves that purpose. In other words, this optimal repricing policy serves as a truncated option contract as mentioned above with a predetermined triggering point of repricing.

Note that the main reason for firms to adopt any repricing alternative is to avoid the "variable charge" following a traditional repricing. Our paper, in contrast with Acharya, John, and Sundaram (2000) and Yang and Carleton (2002), suggests a three-period binomial model to quantify the impact of the marking-to-market feature imbedded in the new accounting rules associated with traditional repricing and to justify the occurrence of repricing alternatives.

The rest of this paper is organized as follows. Section 2 reviews the related literature and accounting rules. Section 3 describes our three-period binomial model and the backward induction procedure to analyze the an-ante optimality of repricing alternatives. In Section 4, we propose an optimal repricing policy that specifies how deeply the options are under water before triggering repricing. Section 5 shows the results, Section 6 discusses, and Section 7 concludes.

2. Literature Review and Accounting Rules

2.1 Literature Review

There are only a few analytical studies from an ex-ante contracting viewpoint conducted on repricing underwater options, in which the strike price is higher than market value. Acharya, John, and Sundaram (2000) (hereafter AJS) study the dynamic optimality of repricing executive stock options and characterize the conditions that affect the relative optimality of repricing. They find repricing can still be a value-enhancing strategy, even from an ex-ante viewpoint. In *some* cases, a repricing strategy almost always dominates a do-nothing strategy. Yang and Carleton (2002) extend AJS by incorporating the economic impacts (through tax effects) resulting from the new accounting rulings associated with repricing to study the optimality of repricing. They find that repricing loses its ex-ante dominance over the do-nothing strategy (as claimed by AJS) after considering dilution effects and the tax effects of new accounting rules associated with repricing. On average, repricing is indifferent from do-nothing in terms of the principal's expected initial payoffs.

Repricing has been studied empirically since the early 1990s. However, as Yang and Carleton (2002) point out, there is no study on repricing using post-1998 data to reflect the accounting rules changes since December 1998. For example, Gilson and Vetsuypens (1993) study repricings by financially distressed firms during 1981-87. Saly (1994) examines repricings following the stock market crash of 1987. Chance, Kumar, and Todd (1997) and Brenner, Sundaram, and Yermack (2000) use repricing data up to 1998 to characterize the repricing incidence by firm-specific factors and market conditions. They find that repricing is more likely to occur in firms with insider-dominated boards.

Chance, Kumar, and Todd (1997) empirically examine the incidence of "direct repricing" (called "traditional repricing" in this paper) -- corporations lowering the exercise prices of existing stock options. They find that the magnitude of the reduction in the exercise price is positively related to the firm's stock price performance and negatively related to the market's performance. More interestingly, Chance, Kumar, and Todd (1997) find no evidence to support the argument that lowering the exercise price leads to an increase in future stock prices. This means that repricing underwater options can be counterproductive and send the wrong signal to employees and shareholders. However, failure to rescue out-of-money stock options may cost the company more by demoralizing the workforce and reducing the firm's ability to retain and attract managerial talent in a competitive labor market.

In this paper, we not only analyze the optimality of repricing strategies from the shareholders' viewpoint, but we also utilize an incentive measure to rank those repricing strategies from the employees' standpoint. Among the most recent papers, Hall and Murphy (2002) show that risk aversion combined with non-diversification derives a gap between the "company cost" and the "executive value" of stock options. Ingersoll (2002) also derives a model to quantify the "objective" and "subjective" values of incentive stock options with a repricing feature imbedded from both ex-ante and ex-post viewpoints. This paper derives the agent's equivalent wealth at time 0 (denoted as w_0) from his/her expected initial utility. We then incorporate w_0 (as the subjective value of the agent's options) into an incentive measure which allows us to rank the repricing strategies under consideration from the employees' viewpoint.

Unlike Acharya, John, and Sundaram (2000) and Yang and Carleton (2002), this paper assumes the agent (or the manager) is risk averse, but the principal (or the public shareholders) remains risk neutral for purposes of analyzing repricing alternatives from a risk-sharing perspective. Furthermore, we let the agent's terminal wealth (therefore, the principal's terminal share value) be path dependent as well as exercise-strategy dependent. We also take into account the agent's personal tax liability resulting from option exercise while analyzing the principal's choice of repricing policies. Like Yang and Carleton (2002), we incorporate the dilution effect of option exercise and the tax effect of new accounting rules associated with repricing in our analysis.

2.2 Accounting Rules

Repricing involves the lowering of the exercise price of a stock option usually when the current exercise price is above the market value of the underlying shares. This has become a sensitive subject since the beginning of 2001, for the following reasons. First, the Financial Accounting Standards Board's (FASB's) final interpretation No 44 of APB Opinion 25 discourages stock option repricings by forcing companies that reset the strike prices of options to take a charge to earnings.[40] Prior to 1999, favorable accounting treatment for stock options was available for repriced options, meaning that appreciation in the value of the underlying shares did not give rise to an accounting charge. FASB has eliminated this favorable accounting treatment for repricings that occur after December

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[40] On March 31, 2000, the FASB's final interpretation No 44 of APB Opinion 25 indicated that if companies wish to expedite the vesting of outstanding options or extend their exercise period after employee termination will need to take action prior to July 1, 2000 to avoid a charge to earnings. In addition, modifications to add automatic reload features to outstanding options should have been made prior to January 12, 2000, after which new accounting charges to earnings will be imposed under final APB Opinion 25.

15, 1998.[41] But the accounting penalty applies only if companies issue lower-priced replacement stock options within six months after the initial options are canceled. In other words, the variable accounting charge can be avoided if the cancellation and new grant are more than six months apart.

Second, there has been a movement, led in part by the former SEC chairman Arthur Levitt, to force companies to seek shareholder approval for employee stock option plans.[42] "It is shareholders' money that officers and directors are using to pay themselves," Levitt said during an address in December 2000 to an audience at the New York Federal Reserve. "Shareholders should not be diluted in the dark. I urge you not to miss the opportunity to comment."

Finally, option repricings seemingly reward employees for a company's falling stock price. Hence, the challenge facing firms is to devise innovative approaches to retaining as well as attracting key talent to achieve the ultimate goal of creating shareholder value in a fair manner.

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[41] FASB's new Interpretation #44 narrows the circumstances under which companies may account for stock awards under the intrinsic value method governed by APB Opinion No. 25 (APB 25), which generally provides for the non-recognition of expense for grants of stock options having fixed terms. Whenever APB 25 accounting is not allowed, FASB Statement 123 requires expense recognition for the fair market value of the option on the date of the grant, spread over the vesting period.

[42] Levitt asked the National Association of Securities Dealers (NASD) to adopt the type of rule proposed by the New York Stock Exchange (NYSE) which would require shareholders' approval before awarding employees options grants. As of July 1, 2001, neither NYSE nor the Nasdaq requires its listed companies

The FASB's interpretation No. 44 (I44) regarding repricings was retroactive to December 15, 1998.[43] Under I44, repricing a stock option is considered a modification of the option that will cause the option to be subject to variable award accounting.[44] If the exercise price of a fixed stock option award is reduced, the award shall be accounted for as variable from the date of the modification to the date the award is exercised, forfeited or expires unexercised. As a result, companies must mark-to-market all repriced options in each quarterly earnings report. The reported earnings will decrease as the intrinsic value of repriced options increases, whereas a subsequent decrease in intrinsic value will increase reported earnings. This impact on a company's income statement will continue until the option is exercised, forfeited, or expires unexercised.

In addition to the marking-to-market effect (or variable effect) mentioned above, companies will have to deduct the difference in value (or fixed effect) between the original stock options and the repriced options from their earnings when the repricing occurs. It is important to note that accounting costs and economic costs are not equivalent. For simplicity, we assume that the tax consequences following reported

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to seek shareholder approval for stock option plans if those plans apply to a large percentage of the companies' employees.

[43] The Interpretation No. 44 , *Accounting for Certain Transactions Involving Stock Compensation—An Interpretation of APB Opinion No. 25* is also intended to resolve the inconsistency between EITF Issue Nos. 87-33, *Stock Compensation Issues Related to Market Decline*, and 94-6, *Accounting for the Buyout of Compensatory Stock Options*, by requiring that all of the originally measured compensation be charged to expense at the time of a buyout.

[44] The provisions of I44 are effective July 1, 2000, and apply prospectively to new awards, exchanges of awards in a business combination, modifications to outstanding awards, and changes in grantee status that occur on or after that date. However, the standards also apply to repricings after December 15, 1998, and modifications to fixed stock option awards to add a reload feature apply to changes made after January 12, 2000.

earnings are the only economic cost associated with the new accounting rules that are considered in our model. The economic impact of those accounting charges on the principal's terminal share value is only shown as a tax deduction (or addition).

For example, an executive has 10 vested stock options exercisable at $20 per share and the firm has 90 shares outstanding. The firm reprices those options when the stock has a quoted market price of $10 per share.[45] Later, but within the same tax year, the quoted market price of the underlying stock increases to $15 per share. At that time, the executive exercises those options. The fixed effect causes a $100 (=10 x $10) deduction from reported earnings and the variable effect causes additional $50 (=10 x $5). If the company faces a tax rate of 30%, the exercise generates a tax benefit for the company of $45 (= .30 x $150) and the number of outstanding shares is 100. The cash inflow of $45 is included in the principal's terminal share value in our model.

Therefore, the trade-off for a firm in repricing underwater options is between tax benefit and diluted share value, assuming that the firms' market values are not so sensitive to reported earnings fluctuation. Note that one main focus of this paper is to examine the optimality of various repricing strategies while considering the economic impact (through taxation) of these accounting charges.

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[45] Assume that the options are repriced at-the-money (hence the new exercise price is $10 per share).

3. Three-period Dynamic Model

Using a three-period binomial model, we analyze the dynamic optimality of repricing strategies for rescuing underwater stock options from the viewpoints of both shareholders (called the "principal", collectively) and managers (called the "agent", collectively). The objective for the principal is to choose an ex-ante repricing strategy imbedded in the initial option-based incentive contract to maximize his/her expected payoff in a situation where repricing of the agent's stock options is inevitable.

The agent, on the other hand, needs to choose an optimal level of effort (or action) at each interim stage to maximize his/her expected terminal utility while deciding whether or not exercise options before the terminal date. Anticipating the agent's actions and exercise strategies, the principal selects a repricing strategy imbedded in the initial option contract to maximize his/her expected initial payoffs given the agent's expected action and payoffs.

Specifically, we use no repricing (hereafter NR) as a benchmark strategy to compare with traditional repricing (TR), delayed repricing (DR), and advanced repricing (AR). In doing so, we allow the agent's expected terminal wealth (therefore the principal's as well) to be contingent upon the path, early exercise strategy, as well as the chosen repricing strategy by the principal.

We also propose an optimal repricing policy from an ex-ante viewpoint to analyze how deeply the options are under water before repricing takes place. In other words, we suggest an optimal degree to which existing options are under water before triggering repricing for each repricing strategy mentioned above. This optimal repricing policy can serve as a truncated option contract as mentioned in the introduction section with a predetermined triggering point of repricing.

There is no information asymmetry: the expected terminal wealth structure and all probability distributions are common knowledge. Put differently, the principal chooses an ex-ante optimal repricing strategy while considering the best responses from the agent at every interim stage. Recall that there is a trade-off between tax benefits and diluted share value as a result of exercising repriced options.

It is helpful to refer to Figure 1 while going through our model description below.

3.1 Dynamic Programming

In our three-period binomial model, dynamic programming is used to not only justify the occurrence of repricing alternatives but also quantify the impact of the marking-to-market feature imbedded in the new accounting rules associated with traditional repricing. Yang and Carleton (2002) find that traditional repricing is indifferent from no repricing in terms of the principal's expected initial payoffs. That conclusion is made without even considering the marking-to-market feature of new variable accounting charges. As a result of these tax impacts and shareholder activism, the traditional repricing in which the exercise price is lowered to then-current market value has been losing its dominance as a solution to rescuing underwater options since 1998. One goal we try to accomplish here is to rationalize the repricing phenomenon and the occurrence of repricing alternatives.

We assume that the manager (the "agent") is risk averse and the owner (the "principal") is risk-neutral. In our three-period model of firm value with dates indexed by t = 0, 1, 2, and 3, all payoffs are assumed to be received at the terminal date t = 3. The terminal payoffs for each party at each interim period are common knowledge. Figure 1 illustrates the binomial structure of the model. At the beginning stage I, the principal hires an agent by offering $\alpha \in (0,1]$ option on the firm's terminal value to run the firm whose only share's initial value is normalized to unity. Note that if the agent exercises in-the-money options, the number of outstanding shares is then $(1+\alpha)$.

The dynamics of firm value (denoted as FV) can be illustrated in Figure 1 as follows:

$$FV_{t+1} = \delta_t FV_t \qquad (t = 0, 1, 2)$$

$$F_0 = 1$$

Here δ_0, δ_1, and δ_2 are assumed to be i.i.d. (independent and identically distributed) stochastic variables, taking only the two values H (= 1 + u) and L (=1 - u) with probabilities

$$P(\delta_t = H) = p(a_x)$$

$$P(\delta_t = L) = 1 - p(a_x)$$

where $p(a_x) = a_x$ and $a_x \in [0, \bar{a}]$ is the agent's action (or level of effort) at node $X \in$ {I, H, L, H^2, HL+, HL-, L^2}. Note that we set $\bar{a} < 1$ to eliminate the possibility of the agent having an absolute influence in reaching next high-value stage. Otherwise, it can be shown that the node L will never be reached and the agent will have the same expected utility at t = 0.

Note that the event tree for the process of firm value (FV) is recombining in the sense that an "up"-move followed by a "down"-move gives the same result as a "down"-move followed by an "up"-move. However, the principal's share value (denoted as f) and the agent's terminal wealth (denoted as w) are contingent upon (1) path; (2) the agent's exercise strategy; and (3) the principal's repricing strategy. Hence, as illustrated in Figure 1, the event tree for both processes is not recombining.

We assume that the repricing will occur at node L, and no layoff and bankruptcy will occur throughout these three periods. The discount rate is assumed to be zero to simplify the notation. Our intention is to capture the impacts of the agent's expected actions and the early exercise strategies in the interim periods, including the continuation effect and feedback effect. The (positive) continuation effect results from higher level of effort by the motivated agent in the subsequent period and therefore generates higher terminal payoffs. On the other hand, the (negative) feedback effect is caused by lack of effort from the agent because of the anticipation of repricing.

3.2 Backward Induction Procedure for the Agent's Optimal Control Problem

Based on Bellman's Principal of Optimality, we adopt the backward induction algorithm to derive the agent's optimal actions and early exercise strategies from an ex-ante viewpoint for each repricing strategy under consideration.[46] Based on the agent's expected actions and exercise strategies, the principal chooses a repricing strategy to maximize his/her own expected initial payoff. The repricing strategies under consideration are no repricing (NR), traditional repricing (TR), delayed repricing (DR), and advanced repricing (AR). We assume the agent is risk averse with a power utility function: $U(w) = (w^{1-\gamma})/(1-\gamma)$, where $\gamma \in [0,1)$ is the coefficient of relative risk aversion. Note that if $\gamma = 0$, the agent is risk neutral. Second, the agent's terminal wealth (therefore, the principal's terminal share value) is path dependent as well as exercise-strategy dependent. Third, we take into account the agent's personal tax liability resulting from option exercise while analyzing the principal's choice of repricing strategy. We assume

[46] Bellman's Principal of Optimality: "*An optimal policy has the property that whatever the initial state and initial decision are, the remaining decisions must constitute an optimal policy with regard to the state*

that the personal tax rate is the same as the corporate tax rate for simplicity and without loss of generality.

3.3 Comparison among Repricing Strategies

From an ex-ante viewpoint, the principal will choose one of repricing strategies (NR, TR, DR, or AR) once node L is reached based on his/her expected payoff at t = 0. Table 1 lists the pros and cons for each strategy. Note that the principal's expected payoff at t = 0 is not only path-dependent but also (the agent's) exercise-strategy-dependent. Hence, we first use backward induction to determine the agent's choice of actions (or level of efforts) at t = 2 to maximize his/her expected terminal utility.

In doing so, we lay out the agent's expected terminal wealth if the agent holds and cashes in his/her options until t = 3 as listed in Table 2. For example, if the path is I → L → HL- → H^2L, the agent's expected terminal wealth (denoted as $w_{5,\ t=3}$) under TR (traditional repricing) is $\alpha(H^2L - L)(1 - t_c)$. Note that α is the number of call options (each with an original strike price of unity) awarded to the agent at time 0. H^2L is the terminal firm value, L is the new strike price of repriced options, and t_c is the personal tax rate. Similarly, Table 3 lists the agent's expected terminal wealth if the agent holds and cashes in his/her options until t = 2.

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resulting from the first decisions." (Page 15, *Applied Dynamic Programming* by Richard E. Bellman and Stuard E. Dreyfus, 1962)

Since the probability of firm value reaching the next high-value stage is equal to the chosen level of effort ($p(a) = a$) by assumption, the agent will choose an exercise strategy (either "HOLD" or "EXERCISE") at t =2 based on whichever gives him/her a higher expected terminal utility. Then we repeat the same procedure backward until we determine the agent's expected values of control variables (action and exercise strategy) in each interim period. According to the expected exercise strategies and actions chose by the agent, we then compute the principal's expected payoff at t = 0 (denoted as V_0) if one of repricing strategies is adopted at node L. Finally, we repeat the above-mentioned procedure for other repricing strategies.

Table 4 lists the principal's terminal share value if the agent holds and cashes in his/her options until t = 3 (denoted as $f_{t=3}$). For instance, if the path is I → L → HL- → H^2L, the principal's expected share value (denoted as $f_{5,\ t=3}$) under TR (traditional repricing) is

$$\frac{H^2L + \alpha L + \pi_c \alpha\ [(1-L)+(H^2L-L)]}{1+\alpha}$$

Recall that we normalize the firm value at t = 0 to unity on the principal's only share. If the agent exercises in-the-money options, the number of outstanding shares is then ($1+\alpha$) and the principal receives (α L) from the agent's exercise. The economic impact of the new accounting rule associated with the traditional repricing (TR) is reflected as $\pi_c\alpha$ [(1 - L) + (H^2L - L)], where π_c is the corporate tax rate.

3.4 The Agent's Expected Actions and Exercise Strategies

Again, let α be the number of call options (each with a strike price of unity) awarded to the agent at time 0. Table 2 shows the agent's terminal wealth ($w_{i,\,t=3}$) at the terminal node i if the agent holds and cashes in his/her options until t = 3. See Figure 1 for the corresponding paths leading to each of eight terminal nodes. We suppress the time subscript for simplicity. Contingent upon reaching the node H^2, the agent solves

$$\max_{a_{hh} \in [0,\bar{a}]} \{ p(H)(\frac{w_1^{1-\gamma}}{1-\gamma}) + p(L)(\frac{w_2^{1-\gamma}}{1-\gamma}) - \frac{1}{2} k a_{hh}^2 \}$$

where $p(H) = p(a_{hh}) = a_{hh} = 1 - p(L)$,

$\gamma \in [0,1)$ is the coefficient of relative risk aversion.

$w_1 = \alpha(H^3 - 1)(1 - t_c)$, and

$w_2 = \max[\,0, \alpha(H^2L - 1)(1 - t_c)]$ (t_c: personal and corporate tax rate) [47]

and k is the coefficient in the disutility function (= $\frac{1}{2}ka^2$) resulting from the agent's effort (a).

Let $U_i = (w_i^{1-\gamma})/(1-\gamma)$. Then the solution is

[47] Assume that the personal tax rate is the same as the corporate tax rate for simplicity and without loss of generality.

$$a_{hh} = \begin{cases} 0 & \text{if} \quad U_1 \leq U_2 \\ (U_1 - U_2)/k & \text{if } 0 < (U_1 - U_2) < k\,\bar{a} \\ \bar{a} & \text{if} \quad (U_1 - U_2) \geq k\,\bar{a} \end{cases} \quad (1)$$

Thus, the agent's expected continuation utility ${}_{C}U_{hh}$ from the node H^2 is given by

$${}_{C}U_{hh} = [a_{hh}][U_1] + [1 - a_{hh}][U_2] - \frac{1}{2}k[a_{hh}]^2 \quad (2)$$

If the agent choose to exercise his/her options at node H^2, then the terminal utility is

$${}_{E}U_{hh} = U(w_{hh}) = (w_{hh}^{1-\gamma})/(1-\gamma) \quad (3)$$

where $w_{hh} = \alpha(H^2 - 1)(1 - t_c)$ is the agent's terminal wealth if the agent holds and cashes in his/her options at node H^2. See Table 3 for details.

At node H^2, the agent's exercise strategy

$$E_{hh} = \begin{cases} 1 \text{ (EXERCISE)} & \text{if } {}_{E}U_{hh} > {}_{C}U_{hh} \\ 0 \text{ (HOLD)} & \text{otherwise} \end{cases} \quad (4)$$

Note that if $E_{hh} = 1$ (or $E_{hl+} = 1$), then $a_{hh} = 0$ (or $a_{hl+} = 0$) and $E_h = 0$. It means that the options cannot be exercised at $t = 1$ and ${}_{E}U_{hh}$ becomes the agent's expected continuation utility at node H^2 (still denoted as ${}_{C}U_{hh}$ for simplicity). Note that as shown in Table 3, $E_{hl+} = E_{ll} = 0$ since the agent will choose to hold his/her out-of-the-money options at nodes HL+ and L^2 no matter which repricing strategy chosen by the principal. Therefore, we compute the agent's expected continuation utility at node HL+ (denoted as ${}_C U_{hl+}$) as

$$ {}_C U_{hl+} = [a_{hl+}][U_3] + [1 - a_{hl+}][U_4] - \frac{1}{2}k[a_{hl+}]^2 \qquad (5) $$

where
$$ a_{hl+} = \begin{cases} 0 & \text{if } \quad U_3 \leq U_4 \\ (U_3 - U_4)/k & \text{if } 0 < (U_3 - U_4) < k\,\bar{a} \\ \bar{a} & \text{if } \quad (U_3 - U_4) \geq k\,\bar{a} \end{cases} \qquad (6) $$

Then we can compute the agent's expected action at node H (denoted as a_h) as

$$ a_h = \begin{cases} 0 & \text{if } \quad {}_C U_{hh} \leq {}_C U_{hl+} \\ ({}_C U_{hh} - {}_C U_{hl+})/k & \text{if } 0 < ({}_C U_{hh} - {}_C U_{hl+}) < k\,\bar{a} \\ \bar{a} & \text{if } \quad ({}_C U_{hh} - {}_C U_{hl+}) \geq k\,\bar{a} \end{cases} \qquad (7) $$

Therefore, the agent's continuation utility from the node H (denoted as ${}_c U_h$) is expected to be

$$ {}_C U_h = [a_h][{}_C U_{hh}] + [1 - a_h][{}_C U_{hl+}] - \frac{1}{2}k[a_h]^2 \qquad (8) $$

If the agent choose to exercise his/her options at node H, then the terminal utility is

$$ {}_E U_h = U(w_h) = (w_h^{1-\gamma})/(1-\gamma) \qquad (9) $$

where $w_h = \alpha(H - 1)(1 - t_c)$ is the agent's terminal wealth if the agent holds and cashes in his/her options until node H is reached.

At node H, the agent's exercise strategy is expected to be

$$E_h = \begin{cases} 1 \text{ (EXERCISE)} & \text{if } {}_{E}U_h > {}_{C}U_h \\ 0 \text{ (HOLD)} & \text{otherwise} \end{cases} \qquad (10)$$

Note that $E_h = 1$ if and only if $E_{hh} \neq 1$ and $E_{hl+} \neq 1$. If $E_h = 1$, then $a_h = a_{hh} = a_{hl+} = 0$. In addition, it is obvious that the agent's exercise strategy at node L, $E_l = 0$.

Then we repeat the same procedure backward until we determine the agent's expected actions (a's) and exercise strategies (E's) in each interim period. We compute the agent's expected utility at t = 0 (denoted as U_0) as

$$U_0 = [a_i][{}_{C}U_h] + [1 - a_i][{}_{C}U_l] - \frac{1}{2}k[a_i]^2 \qquad (11)$$

where a_i is the agent's action (or level of effort) at the initial node i.

According to the expected exercise strategies and actions chose by the agent, we then compute the principal's expected payoff at t = 0 (denoted as V_0) for one of repricing alternatives adopted at node L. Finally, we repeat the above-mentioned procedure for other repricing strategies. The Appendix B describes the backward induction procedure in detail.

4. The Optimal Repricing Policy

We propose an optimal repricing policy for each considered repricing strategy (TR, DR, or AR), which specifies how deeply the options are under water at t = 1 before repricing takes place at node L. In other words, given a repricing strategy, the principal sets a triggering point at t = 0 (denoted as C) for repricing, if any, to take place at node L while considering the agent's best response at the initial node I (denoted as a_i) to this policy. For simplicity, we assume that repricing can only occur at node L or never. This assumption is also set to keep track of the risk-sharing perspective and the marking-to-market feature of the new accounting charges associated with traditional repricing (TR) while comparing different repricing alternatives.

At the initial node I, the end node in a backward induction procedure as mentioned in Section 3, the agent will choose an action (a_i) and the principal will set a triggering policy (C) simultaneously. The combination of strategies chosen by both participants determines a payoff for each one. We assume that it is common knowledge that both the principal and the agent are rational. That is, the principal knows that the agent will choose an action to maximize his/her own expected utility at t = 0 given the triggering policy (C) set by the principal. The agent knows that the principal will set a triggering policy to maximize his/her own expected payoff at t = 0 given the expected action from the agent. Furthermore, each participant is willing to choose the strategy predicted by the other. In other words, each participant's strategy is the best response to the predicted strategy of the other. We will derive the necessary and sufficient conditions for the Nash equilibria described above in this section.

There will be no repricing at node L if C > u, where $C \in [0,1]$. Since we normalize the initial firm value to unity, u is simply the percentage drop in firm value at node L. Recall that $u \in (0,1)$ is an exogenous variable, represents the variability of firm value (FV) in next period: $FV_{t+1} = \delta_t FV_t$, where $\delta_t = H$ (= 1 + u) or L (= 1 - u). Therefore, the agent will be expected to choose an action (or level of effort) at t = 0 the same as that under no-repricing (NR) if C > u. Otherwise (if $C \leq u$), the agent will choose an action at t = 0 as same as that under one of repricing strategies (TR, DR, or AR). Meanwhile, if the principal sets C = 0, repricing will occur with a probability of one as long as node L is reached. On the other hand, setting C = 1 means that the principal chooses not to reprice underwater options at node L regardless of market conditions (since u < 1 by assumption). We further assume that u is uniformly distributed between (0,1) to derive the Nash equilibria of an optimal repricing policy while allowing u to be expected homogeneously by both the principal and the agent.

Let U_l^R (U_l^{NR}) be the agent's expected utility at node L with repricing (no repricing), which is derived from the backward induction procedure mentioned above. Since u is assumed to be uniformly distributed between (0,1), the agent's expected utility at node L given a triggering policy (C) is

$$U_l^C = C\,U_l^{NR} + (1 - C)\,U_l^R \tag{12}$$

Note that the probability of no repricing at node L is equal to the probability of (C > u), which is equal to C. Hence, the agent solves

$$a_i^* = \arg\max_{a_i \in [0,\bar{a}]} \{ a_i U_h + (1 - a_i) U_l^C) - \frac{1}{2} k a_i^2 \} \tag{13}$$

where U_h is the agent's expected utility at node H. Then the agent's expected action at the initial node I is

$$a_i^* = \begin{cases} 0 & \text{if } (U_h - U_l^C) \leq 0 & (14) \\ (U_h - U_l^C)/k & \text{if } 0 \leq (U_h - U_l^C) < k\,\bar{a} & (15) \\ \bar{a} & \text{if } (U_h - U_l^C) \geq k\,\bar{a} & (16) \end{cases}$$

Therefore, the agent's expected utility at t = 0 is

$$U_0^* = a_i^* U_h + (1 - a_i^*) U_l^C - \frac{1}{2} k (a_i^*)^2 \tag{17}$$

Simultaneously, the principal sets C* to maximize his/her expected payoff at t = 0 while expecting the agent to choose a_i^* . Hence,

$$C^* = arg \max_{C \in [0,1]} V_0^* = \{ a_i^* V_h + (1 - a_i^*) V_l^C \} \quad (18)$$

where V_l^C is the principal's expected payoff at node L given a triggering policy (C), which

$$V_l^C = C\, V_l^{NR} + (1 - C)\, V_l^R . \quad (19)$$

Note that V_l^R (V_l^{NR}) is the principal's expected payoff at node L with repricing (no repricing), which is derived from the backward induction procedure mentioned in Section 3. Hence, the principal's expected payoff at t = 0 is

$$V_0^* = a_i^* V_h + (1 - a_i^*) V_l^{C^*} \quad (20)$$

From equations (14) through (20), we derive each participant's best response to the predicted strategy of the other, namely (a_i^* , C*), with the necessary and sufficient conditions under which the Nash equilibria hold. The Appendix C provides the proof for the *Proposition 5* as described below. The proofs of other propositions follow a similar procedure.

Proposition 1: (a_i^* , C*) = (0, 1) if and only if ($V_l^{NR} \geq V_l^R$) and ($U_l^{NR} \geq U_h$). In this equilibrium, the agent has no incentive to spend any effort at t = 0 while the principal sets a triggering policy under which repricing is not considered possible. Conversely, anticipating no repricing (C* = 1), the agent will still choose $a_i^* = 0$ because ($U_l^{NR} \geq U_h$).

Proposition 2: (a_i^*, C*) = (0, 0) if and only if ($V_l^{NR} \leq V_l^R$), ($U_l^C \geq U_h$), and ($U_l^R \geq U_h$). In this equilibrium, the agent has no incentive to spend any effort at t = 0 because the principal sets a triggering policy under which repricing is considered at node L with a probability of one. The converse is also true: the principal sets C* = 0 because he or she expects $a_i^* = 0$ anyway if $U_l^R \geq U_h$.

Proposition 3: (a_i^*, C*) = ($\bar{a}$, 1) if and only if ($V_l^{NR} \geq V_l^R$) and ($U_l^{NR} \leq U_h - k\bar{a}$). In this equilibrium, the agent spends the highest level of effort at t = 0 to avoid reaching node L because the principal is expected to set a triggering policy under which repricing is not considered possible (C* = 1).

Proposition 4: (a_i^*, C*) = ($\bar{a}$, 0) if and only if ($V_l^{NR} \leq V_l^R$) and ($U_l^R \leq U_h - k\bar{a}$). In this equilibrium, the agent is expected to spend the highest level of effort at t = 0 and the principal to set a triggering policy under which repricing will occur at node L with a probability of one.

Proposition 5: If and only if ($U_h - k\,\bar{a} < U_l^C < U_h$), and (0 < A < 1), where

$$A = \frac{(U_l^{NR} - U_l^R)(V_h - V_l^R) + (V_l^{NR} - V_l^R)(U_h - k - U_l^R)}{2\ (U_l^{NR} - U_l^R)(V_l^{NR} - V_l^R)}, \tag{21}$$

then

$$\begin{cases} a_i^* = (U_h - U_l^{C*})/k & \text{and} \quad (22) \\ C^* = A & \quad (23) \end{cases}$$

where $$U_l^{C*} = C^*\, U_l^{NR} + (1 - C^*)\, U_l^R \tag{24}$$

In this equilibrium, the agent will take an action of a_i^* at t = 0 and the principal is expected to set a triggering policy C* = A under which repricing will not occur unless $u \geq C^*$.

Proposition 6: $(a_i^*, C^*) = ((U_h - U_l^{NR})/k,\ 1)$ if and only if $(U_h - k\,\bar{a} < U_l^{NR} < U_h)$, $(V_l^{NR} \geq V_l^R)$, and [$A \notin (0,1)$ or $(U_h - k\,\bar{a} \geq U_l^C)$]. In this equilibrium, the agent will take an action of a_i^* at t = 0 and the principal is expected to set a triggering policy under which repricing is not considered possible.

Proposition 7: $(a_i^*, C^*) = ((U_h - U_l^R)/k,\ 0)$ if and only if $(U_h - k\,\bar{a} < U_l^R < U_h)$, $(V_l^{NR} \leq V_l^R)$, and [$A \notin (0,1)$ or $(U_h - k\,\bar{a} \geq U_l^C)$]. In this equilibrium, the agent will take an action of a_i^* at t = 0 and the principal is expected to set a triggering policy under which repricing will occur at node L with a probability of one.

We then compute the principal's expected payoff at t = 0 (V_0^*) and the agent's expected utility at t = 0 (U_0^*) accordingly.

5. Results

In this section, we use an example to illustrate the dynamics of the agent's chosen actions and exercise strategies in every interim period and for each considered repricing strategy. There are four repricing strategies under consideration: no-repricing (NR), traditional repricing (TR), delayed repricing (DR), and advanced repricing (AR). In the backward induction procedure, we set $\alpha = 0.3$, $k = 0.3$, and u = 0.4 in this example. Note that α is the initial option grant, k is the coefficient in the disutility function (= $\frac{1}{2}ka^2$) resulting from the agent's effort (a) and u is an exogenous variable representing the variability of firm value in next period: $FV_{t+1} = \delta_t FV_t$ where δ_t = H (=1+u) or L (=1-u). The assumed quadratic disutility function emphasizes increasing marginal costs for the risk-adverse agent. We also set $\bar{a}$ = 0.8 in this example. Recall that the probability of reaching the next high-value stage given a_x is $p(a_x) = a_x$ and $a_x \in [0, \bar{a}]$ is the agent's action (or level of effort) at node $X \in \{I, H, L, H^2, HL+, HL-, L^2\}$.

5.1 The Agent's Expected Actions and Exercise Strategies

Table 6 illustrates the agent's expected actions (a_x's) and exercise strategies (E_x's) at the indicated nodes X's given $\alpha = 0.3$, $k = 0.3$, and u = 0.4. If the agent is risk neutral ($\gamma = 0$) as assumed in Yang and Carleton (2002), Table 6 (A) shows the trade-off between the (positive) continuation effect and the (negative) feedback effect resulting from repricing. For example, under the delayed repricing (DR), the agent chooses a higher level of effort at nodes HL- (a_{hl-} = 0.22176), L^2 (a_{ll} = 0.09504), and L (a_l = 0.02007) than those under no repricing (NR). However, a lower level of effort is chosen by the agent at node I under TR, DR, and AR than under NR.

Overall, the principal is better off, on average, in terms of expected payoff at t = 0 (V_0) under any repricing strategy under consideration (namely, TR, DR, or AR) than under NR if the agent is risk neutral. This result is consistent with Yang and Carleton (2002) in which the agent is assumed to be risk neutral. Not surprisingly, DR is the only repricing strategy (among two others), which provides incentives to the agent at node L^2 (a_{ll} = 0.09504) since new replacement options are granted at a strike price of L^2. In this particular case, the principal will prefer AR to TR or DR in terms of V_0, which is different from what we might expect because of the double-dilution concern resulting from AR. As for the exercise strategies, the agent chooses to early exercise his/her options at node H^2 under all four repricing policies and node HL- under traditional repricing (TR).

When the agent is risk averse ($\gamma = 0.5$), Table 6 (B) shows that comparing with NR, DR has a positive continuation effect at node L^2 ($a_{ll} = 0.8$) but a negative feedback effect at node L ($a_l = 0.475$). In other words, the agent spends less effort during the 6-month out-of-market period (from t = 1 to t = 2) until node L^2 is reached under the delayed repricing (DR). The agent's expected utility (U_0) increases (from 0.4614 to 0.4893) and the principal's expected payoff (V_0) decreases (from 1.7311 to 1.7194). Loosely speaking, this result also confirms with public shareholders' concern: Repricing underwater options benefits executives at shareholders' expense.

Like DR, the advanced repricing (AR) also gives the agent a higher expected utility at t = 0 and the principal a lower expected payoff than those under the no-repricing strategy. However, AR has a positive continuation effect at node L ($a_l = 0.8$) but there is no effort expected at node HL- ($a_{hl-} = 0$) because of an early exercise. Recall that if AR occurs at node L, new α options will be granted immediately at a strike price of L while keeping old options until t = 3. Hence, the agent exercises his/her new options at node HL- and keeps the old options until the terminal date. As a result of double dilution, the principal has a lowest expected payoff at t = 0 under AR than under other repricing policies.

When the agent is extremely risk averse (γ = 0.9), Table 6 (C) shows that traditional repricing (TR) will cause an early exercise from the agent at node HL- and therefore there is no effort expected after the exercise ($a_{hl-} = 0$). Unlike previous two cases (γ = 0 and γ = 0.5), this case shows that the principal is worse off in terms of expected payoff at t = 0 under TR than under NR from an ex-ante viewpoint. Put differently, the principal is better off under TR than NR unless the agent is extremely risk averse.

If the principal expects to reach node L^2 after repricing occurs at node L, the delayed repricing (DR) may be the most favorite choice among the four policies under consideration. Table 6 (C) shows that DR will encourage the agent to spend the highest level of efforts at L^2 ($a_{ll} = 0.8$) and give the principal a higher V_0 than NR. If advanced repricing (AR) occurs at node L, we will expect an extreme negative feedback effect at the initial node I ($a_i = 0$) and an early exercise at HL-. Moreover, the principal's expected payoff at t = 0 (V_0) decreases from 1.7511 to 0.4792 (a 72.64% deduction) if the agent is extremely risk averse.

5.2 Measure of the Incentive Provided by Each Repricing Strategy

How much incentive does each repricing strategy provide? Among others, Ingersoll (2002) suggests that the incentive be the change in value as perceived by the manager (the agent) relative to the change in shareholders' (the principal's) wealth. Therefore, we are interested in examining an incentive measure for the agent (denoted as $A_I \equiv \Delta w_0/\Delta V_0$) provided by TR, DR, and AR while comparing to no repricing (NR). On the other hand, we consider the reciprocal of A_I (namely, $\Delta V_0/\Delta w_0$) the principal's decision-making criterion (denoted as P_I) for choosing a repricing strategy at node L. Note that w_0 is the agent's equivalent wealth at t = 0, which is derived from $U_0 = (w_0^{1-\gamma})/(1-\gamma)$, where $\gamma \in [0,1)$ is the coefficient of relative risk aversion.

From the results in Table 6, we prepare Table 7 to examine the incentive measure for each repricing strategy from both the agent's and the principal's perspectives. Table 7 (A) shows that if the agent is risk neutral ($\gamma = 0$), the agent will prefer TR and the principal will prefer AR in terms of U_0 and V_0, respectively. Under TR, the agent will expect to increase his/her wealth by 8.41 cents (better than DR and AR) per dollar increase in the principal's payoff. However, under AR, the principal will expect to increase his/her payoff by \$27.15 per dollar increase in the agent's expected initial wealth.

In other words, if the agent is risk neutral, TR provides more incentive than DR and AR but the principal will be better off choosing AR to have a higher expected payoff at t = 0. Hence, choosing either repricing alternative (DR or AR) to avoid the accounting charges associated with TR will be a suboptimal choice for the principal if providing incentive is the main reason to reprice underwater options. More interestingly, both the agent and the principal will be better off in terms of expected initial wealth as long as (any) repricing occurs at node L and the agent is risk neutral.

When the agent is risk averse with $\gamma = 0.5$, Table 7 (B) shows that under DR and AR, the agent increases his/her expected wealth at t = 0 while the principal's expected payoff is decreasing. For instance, under DR, the agent will gain 56.41 cents per dollar decrease in the principal's payoff. From the principal's viewpoint, AR is the least favorable choice among the three repricing policies because the principal will lose \$3.26 per dollar increase in the agent's expected initial wealth.

Hence, in this case, traditional repricing (TR) may well be the win-win strategy if repricing has to occur at node L. TR is the only repricing strategy among other two alternatives, which will increase the principal's expected initial payoff (V_0). This result throws doubt upon the decision of choosing one of repricing alternatives just to avoid the variable accounting charge associated with traditional repricing. On the other hand, if the agent is extremely risk averse ($\gamma = 0.9$) as shown in Table 7 (C), delayed repricing (DR) becomes the only win-win strategy. This interesting result may relieve the agent from being out of the market for six months without knowing the future exercise price under the delayed repricing (DR).

5.3 Subjective Value of Executive Stock Options

There is no closed-form solution for valuing American options with early exercise. In our model, we also have an effort-dependent distribution for the firm value to emphasize the incentive effect of executive stock options (ESOs). Furthermore, we include the repricing feature and the economic effect of variable accounting charges associated with repricings into the valuation of ESOs. The agent's personal tax is taken into account as well. The expected perceived value of ESOs by the agent is defined as the subjective value of ESOs.

Ingersoll (2002) uses the agent's marginal utility function as a martingale pricing process to compute a subjective value of ESOs. We simply use a backward induction procedure to determine the agent's actions and exercise strategies in every interim period. Then we compute the agent's expected utility at t = 0 (denoted as U_0) from an ex-ante viewpoint. Based on $U_0 = (w_0^{1-\gamma})/(1-\gamma)$, we derive the agent's equivalent wealth at t = 0 (denoted as w_0) as the subjective value of ESOs.

Table 7 shows that w_0 increases first and decreases later when the coefficient of relative risk aversion (γ) changes from zero to 0.5 then to 0.9 for each repricing alternative. For example, under the traditional repricing strategy (TR), w_0 = 0.0092, 0.0624 and 0.0457 if γ = 0, 0.5, and 0.9, respectively. Our detailed results (not reported here) show that if the agent is risk averse, the subjective value of options to the agent (w_0) decreases with the degree of risk aversion. Given $\gamma > 0$, the advanced repricing (AR) always gives the agent the highest w_0 (or U_0) but the principal the lowest V_0. Unless the agent is extremely risk averse (i.e., γ = 0.9), the agent prefers TR to DR (therefore, AR $\succ$ TR $\succ$ DR) in terms of expected wealth at t = 0. The opposite is true (DR $\succ$ TR $\succ$ AR) for the principal. This result is consistent with the public shareholders' double-dilution concern from AR. The agent's preference order about DR justifies the worry that he/she will be "out-of-the-market" for six months without knowing the future exercise prices.

Interestingly, Table 7 (A) shows that if the agent is risk neutral (γ = 0), the preference order in terms of V_0, for the principal is AR $\succ$ TR $\succ$ DR while the order in terms of U_0 for the agent is TR $\succ$ AR $\succ$ DR. In other words, the occurrence of advanced repricings (ARs) is justified from the principal's viewpoint only if the agent is risk neutral. In any case, the delayed repricing (DR) is the least favorite choice from both the principal's and the agent's standpoints as long as the agent is risk neutral.

6. Discussion

In this Section, we discuss the agent's expected actions and exercise strategies, the principal's optimal repricing policy, and the estimated agency costs based on simulation results. For each repricing strategy (NR, TR, DR, or AR), we average the statistics under consideration over the space of $\{\alpha , u, \gamma, k\}$. Note that α is the initial option grant, u is the variability of firm value in every subsequent period, γ is the coefficient of relative risk aversion, and k is the coefficient in the agent's disutility function ($=\frac{1}{2}ka^2$) resulting from the agent's action (a). The assumed quadratic disutility function emphasizes increasing marginal costs for the risk-adverse agent. In simulation, we set a's are within [0, 0.8], α's within [0.1, 1], u's within [0.1, 0.9], γ's within [0, 0.9], and k within [0.1, 1]. The tax rate is assumed to be 0.34 at both personal and corporate level.

6.1 The Agent's Expected Actions and Exercise Strategies

Table 8 shows that the agent's expected actions (a_x's) and exercise strategies (E_x's) at the indicated nodes X's. DR (delayed repricing) is the only strategy that provides the agent any incentive at node L^2 (a_{ll} = 0.4880) but less incentive at node L (a_l = 0.3629) than under TR or AR. In other words, the agent spends less effort during the 6-month out-of-market period (from t = 1 to t = 2) until node L^2 is reached under DR. On the other hand, if node HL- is reached, the agent is expected to make a highest level of effort

(a_{hl-} = 0.6055) to gain a higher probability of being in-the-money for the new option grant (with a strike price of HL) at t = 3. Overall, DR gives the principal the highest expected initial payoff (V_0 = 1.2841) and the agent an expected utility at t = 0 (U_0 = 1.4698) in between TR and AR.

Under TR and AR, repriced options with a strike price of L indeed provide the agent better incentive at node L than under DR. At node HL-, however, the agent is expected to make less effort than under DR and even NR (no-repricing) because the agent will early exercise his/her repriced options at HL- with probabilities of 78.75% and 63.56% under TR and AR, respectively. It is important to note that AR causes a significant (negative) feedback effect at the initial node I (a_i = 0.4643), which consequently translates into a lower expected initial payoff (V_0 = 1.1582) for the principal than under NR. This result confirms with public shareholders' concern: (Advanced) repricing benefits executives at shareholders' expense. Overall, AR gives the agent the highest expected initial utility (U_0 = 1.7567) and the principal the lowest expected payoff at t = 0.

Interestingly, Table 8 also shows that TR (traditional repricing) provides most incentive for the agent in terms of the increase in the agent's wealth per dollar increase in the principal's payoff. (denoted as $\Delta w_0/\Delta V_0$).[48] Note that w_0 is the agent's equivalent wealth at t = 0, which is derived from $U_0 = (w_0^{1-\gamma})/(1-\gamma)$, where $\gamma \in [0,1)$ is the coefficient of relative risk aversion. Specifically, under TR, the agent will expect to increase his/her wealth by $1.40 per dollar increase in the principal's expected payoff at t = 0, which is almost twice as much as that under DR. As discussed above, the incentive measure for AR is negative ($\Delta w_0/\Delta V_0$ = -1.3039).

Hence, choosing either repricing alternative (DR or AR) to avoid the accounting charges associated with TR will be a suboptimal choice for the principal if providing incentive is the main reason to reprice underwater options. Meanwhile, AR will benefit the agent (or executives) most at the principal's (or public shareholders') expense, and DR will provide the principal more expected payoff at t = 0 than any other repricing strategy.[49] Not surprisingly, the agent will be better off in terms of expected utility at t = 0 (or equivalent wealth, w_0) than under NR (no-repricing) as long as (any) repricing occurs at node L.

6.2 The Optimal Repricing Policy

Tables 9, 10, and 11 show the optimal repricing policy under TR, DR, and AR, respectively. The optimal repricing policy (C*) combined with the agent's best initial response (a_i^*) specifies how deeply the options are under water before triggering any repricing at node L. Given a repricing strategy (TR, DR, or AR), k, α, and γ, we

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[48] This result holds even if the agent is risk neutral as shown in Table 7.

simultaneously determine (a_i^* , C*) in one of the seven propositions as described in Section 4 while drawing u's from a uniform distribution between (0,1). We average the statistics as indicated over 5,000 random draws of u's given (k, α, γ) and then over the parameter space of (k, α, γ). In simulation, we set k's are within [0.1, 1], α's within [0.1, 1], and γ's within [0, 0.9]. Recall that C* = 0 means that repricing will occur with a probability of one as long as node L is reached. On the other hand, C* = 1 means that the principal will not reprice underwater options at node L regardless of market conditions (since u < 1 by assumption).

We summarize the results from Tables 9 through 11 as follows:

(1) *Proposition 1*: (a_i^* , C*) = (0, 1) never occurs.

(2) *Proposition 2*: (a_i^* , C*) = (0, 0) only occurs if AR is adopted at node L and the agent is risk adverse. In this equilibrium, the agent will spend no effort at t = 0 because the principal sets a triggering policy under which repricing is considered at node L with a probability of one. Conversely, the principal sets C* = 0 because he or she expects a_i^* = 0 anyway if $U_l^R \geq U_h$. Table 11(B) shows that the principal will set C* = 0 while expecting a_i^* = 0, only when the agent has a high cost parameter k (on average, k = 0.7898). Nonetheless, from (1) and (2), it is not

[49] However, Table 8 shows that V_0 = 1.2841 under DR is not (statistically) significantly higher than V_0 = 1.2783 under TR

surprising to see the principal disregards any repricing policy associated with $a_i^* = 0$.

(3) *Propositions 1,2,* and *3* never occur if the agent is risk neutral.

(4) Panels (A)'s show that if the agent is risk neutral, the probabilities of C* = 0 (*Propositions 4* and *7* combined) are 88.24%, 99.67%, and 98.65% under TR, DR, and AR, respectively. The intuition is that in *Proposition 4*, the agent will make the highest level of effort ($\bar{a}$) to avoid node L regardless of C*. In case of *Proposition 7*, the principal's expected payoff at node L is higher under repricing than under no-repricing ($V_l^R > V_l^{NR}$).

(5) Panels (B)'s show that if the agent is risk adverse, the weighted average triggering points (C*'s) are 31%, 23%, and 31% under TR, DR, and AR, respectively. The probabilities of C* = 0 (*Propositions 4* and *7* combined) are 68.22%, 76.79%, and 67.90% under TR, DR, and AR, respectively. Recall that C* = 0 means repricing at node L will occur with a probability of one once node L is reached. In Section 5 and Subsection 6.1, we show that the principal will have a higher expected payoff at t = 0 under DR than under any other repricing strategy under consideration if repricing will occur at node L with a probability of one once node L is reached. Hence, it is consistent to see the principal set an optimal repricing policy under DR, which C* = 0 is more likely to occur than under other repricing strategies. Therefore, we will expect the principal to set a lower triggering point under DR as a result.

(6) *Proposition 3*: (a_i^* , C*) = ($\bar{a}$, 1) will be more likely to occur when the agent is more risk-adverse. For example, Table 9 (B) shows that the average γ= 0.72 under TR (γ = 0.71 under DR or AR as indicated in Table 10 (B) and Table 11 (B)). In this case, no repricing is necessary because (V_l^{NR} $\geq$ V_l^{R}) and the agent will make the highest level of effort ($\bar{a}$) to avoid node L anyway.

(7) *Proposition 4*: (a_i^* , C*) = ($\bar{a}$, 0) will be more likely to occur when u is high and more options (α) at stake. For example, Table 9 (B) shows that the average price drop is 75% and α = 0.6063 before TR occurs.

(8) *Propositions 5* and *6* will be more likely to occur when *k* is high. If we compare TR with repricing alternatives (DR and AR), *Proposition 6* (C* = 1) suggests that no repricing take place at node L if TR is the chosen strategy and γ is relatively low (i.e., γ = 0.23 as indicated in Table 9 (B)). The expected effort at the initial node I from the agent, a_i^* = 0.09, on average. If DR (AR) is the chosen repricing strategy, the average γ = 0.67 (γ = 0.69) before *Proposition 6* occurs. The much-improving initial effort from the agent a_i^* = 0.73 (0.74) under DR (AR). Recall that as shown in Table 8, TR provides most incentive for the agent in terms of the increase in the agent's wealth per dollar increase in the principal's payoff. However, if the agent is less risk-adverse and the conditions that suffice *Proposition 6* hold, the principal will not expect a_i^* higher than 0.1 if TR is the chosen strategy. Then the principal set C* = 1 (meaning no repricing)

accordingly. On the other hand, under repricing alternatives (DR or AR), a high $a_i^* > 0.73$ is expected if the agent is relatively more risk-adverse ($\gamma > 0.67$). Hence, repricing will not induce the agent to spend more effort at the initial node.

(9) *Proposition 7* in Table 9 (B) suggests that from an ex-ante viewpoint, TR will follow a 36.01% drop, on average in the strike price. This ex-ante prediction is very close to the ex-post empirical finding (a mean 39.1% and median 40.1% drop) by Brenner, Sundaram and Yermack (2000). They used Standard and Poor's ExecuComp database between 1992 and 1995, but the new accounting rules associated with traditional repricing did not take effect until July 2000.

6.3 Agency Costs

We define the agency cost as the difference in expected initial payoffs between each principal-agent case with different repricing strategy and the base case of sole-proprietorship. In each case, we compute the principal's mean expected payoff at $t = 0$ (mean V_0) by integrating V_0's over the parameter space of $\{\alpha, u, \gamma, k\}$. We assume that the sole owner-manager has the same disutility function resulting from his/her efforts as the agent's in the principal-agent framework. The agent is assumed to be risk adverse with $\gamma \in [0.1, 0.9]$.

Table 12 (A) shows that if the principal is risk neutral ($\gamma = 0$), the estimated agency cost averages 27.26% under DR and ranges from 18.46% to 51.78% given different α's while averaging the principal's expected initial payoff over the parameter space of {u, γ, k}. We find that agency costs monotonically decrease as α increases, which implies that granting options indeed aligns the agent's interests with the principal's. In terms of agency costs, DR (AR), again, is the least (most) costly choice among the repricing strategies under consideration.

Table 12 (B) shows that if the principal is risk adverse ($\gamma \in [0.1, 0.9]$), the principal will be better off in principal-agent relationship than in sole-proprietorship except under AR. The estimated agency benefit averages 5.92% under DR, 5.22% under TR, and 4.44% under NR. On average, AR costs the principal 5.62% in terms of expected payoff at $t = 0$ and ranges from 41.01% of cost to 7.45% of benefit, depending on the initial option grant α's. Again, the agency costs (benefits) monotonically decrease (increase) as α increases. Nonetheless, the preference order for the principal should be DR $\succ$ TR $\succ$ NR $\succ$ AR in terms of agency costs as long as the agent is risk adverse.

7. Conclusions

In practice, traditional repricing (TR) has become obsolete since new accounting rules took effect in July 2000. To avoid associated variable accounting charges that cause uncertainty in future reported earnings, companies have tried several repricing alternatives as solutions to rescuing underwater options. Earnings management alone, however, does not justify the occurrence of some repricing alternatives from public shareholders' viewpoint. We show that, from an ex-ante standpoint, advanced repricing (AR) as an alternative almost always benefits the agent at the principal's expense because of early exercise, dilution effect, and less effort (from the agent) at the initial stage, resulting from the agent's anticipation of AR as a protection.

The main reason why firms reprice underwater options in the first place is to provide incentive to demoralized executives when the stock market plummeted. In that regard, we show that TR provides most incentive for the agent in terms of the increase in the agent's wealth per dollar increase in the principal's payoff while comparing with two repricing alternatives under consideration: delayed repricing (DR) and advanced repricing (AR). Hence, choosing either repricing alternative (DR or AR) to avoid the accounting charges associated with TR will be a suboptimal choice for the principal if providing incentive is the main reason to reprice underwater options.

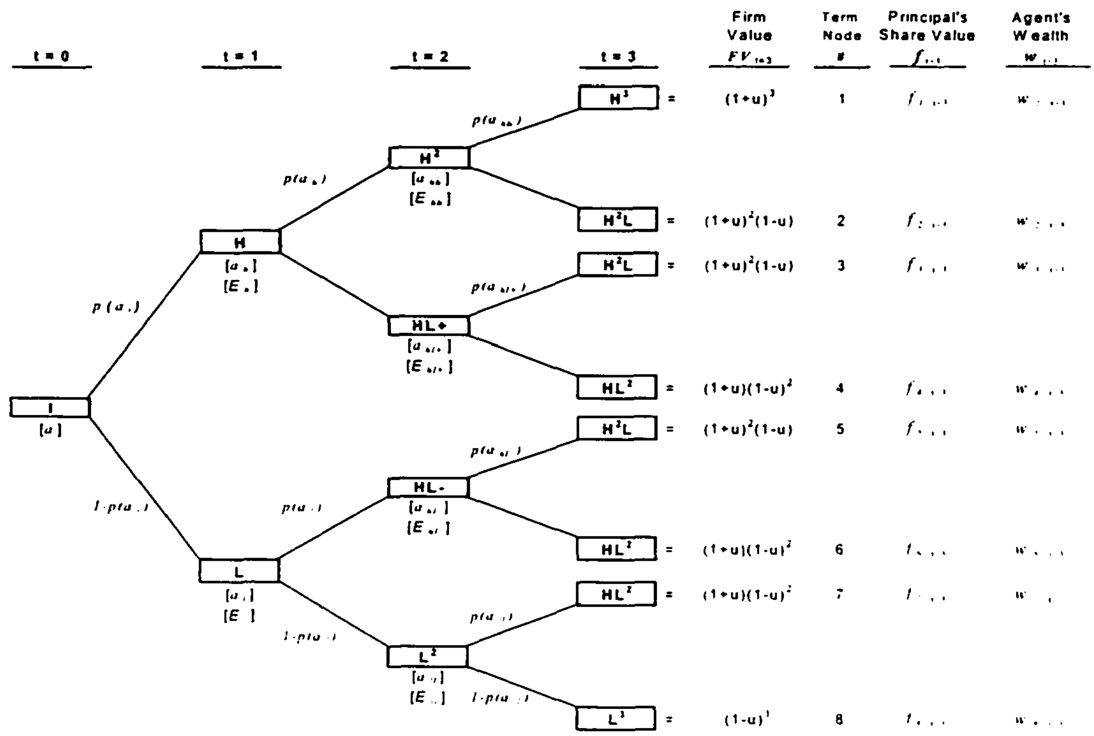
DR gives the principal the most expected initial payoff (V_0) and AR the least if the agent is risk adverse. Specifically, the preference order for the principal is DR $\succ$ TR $\succ$ NR $\succ$ AR, where NR is the no-repricing strategy. Note that TR and AR will cause a high probability that the agent will early exercise repriced options at node HL- and therefore less effort after the exercise. DR, on the other hand, provides the agent incentives to work harder at nodes HL- and L^2, which outweighs the negative effect caused by the less effort at node L. The estimated agency costs (or benefits, if any) show the same preference order for the principal.

For the agent, the preference order is AR $\succ$ TR $\succ$ DR $\succ$ NR in terms of the agent's expected utility at t = 0, which means that any repricing will benefits the agent. These preference orders confirm with public shareholders' concern: AR benefits executives at shareholders' expense. Meanwhile, the agent's preference order about DR justifies the worry that he/she will be "out-of-the-market" for six months without knowing the future exercise prices. It is also important to note that AR causes a significant (negative) feedback effect at the initial node I, which consequently translates into a lower expected initial payoff for the principal than under NR. Overall, AR gives the agent the highest expected initial utility and the principal the lowest expected payoff at t = 0.

Finally, we propose an optimal repricing policy for each repricing strategy, which specifies how deeply the options are under water before repricing takes place at node L. This optimal repricing policy can be used for designing an option-based compensation contract with a predetermined triggering point of repricing. If the stock price hits the predetermined threshold, repricing takes place. Our simulation results under each optimal repricing policy provide predictions about the conditions under which repricing is more likely to occur. The conditions that need to be specified in an option contract include the agent's characteristics (k and γ), and the amount of initial option grant (α). In addition to serving as an option contract, the optimal repricing policy also provides predictions about market conditions (u's) that suggest how much the stock price actually decreases when repricing is triggered under each policy. To verify these predictions is an interesting empirical exercise.

Figure 1: A three-period binomial model and distribution of terminal cash flows.

The firm value at t = 3 (denoted $V_{t=3}$) is exogenously determined. $V_{t+1} = dV_t$ where d = H (=1+u) or L (=1-u) and V_0 = 1. We denote $f_{t=3}$ and $w_{t=3}$ for the principal's share value at t =3 and the agent's wealth at t =3, respectively, assuming that the agent holds his/her options until the terminal date (t = 3) to begin our backward induction analysis.



where $p(a_x) = q\ m + (1\text{-}q)\ a_x$ or $p(a_x) = a_x$ if $q = 0$ in some cases

Parameters/Variables	Range	Descriptions
α	(0, 1]	A parameter: the option contact offered by the principal at node I.
a_X	[0, a']	A control variable: the action (or effort level) taken by the agent at node X. Note that $a' < 1$.
E_X	{0,1}	A control variable: the exercise strategy taken by the agent at node X (e.g., E_X =1 if exercised).
$p(a_X)$	[0, 1)	The probability of reaching node X given the agent's action a_X.
q	[0,1]	A parameter: the extent to which the agent's action may influence $p(a)$. If q =0, $p(a) = a$.
m	[0,1]	A parameter: the influence of external factors on $p(a)$.
u	(0,1)	An exogenous variable: the variability of firm value in next period: $FV_{t+1} = \delta_t\ FV_t$ where δ_t = H (=1+u) or L (=1-u).

Table 1: Traditional Repricing and Its Alternatives

	Alternatives	How	Notes/Concerns
(0)	"Traditional repricing"	Change the exercise price of the underwater options to current market value.	The repriced options are subject to variable award accounting.
(1)	"Delayed repricing" or "6&1" Method	Cancel underwater options and reissue them six months and one day later.	Avoid the variable accounting charge to earnings under the new accounting rules. Employees will be "out-of-the-market" for 6 months without knowing the future exercise prices.
(2)	"Advanced repricing"	Grant new options at market price up front in return for surrender of old grants by the employees after six months and one day.	Avoid the variable accounting charge to earnings under the new accounting rules. Shareholders' concern is the potential double dilution.
(3)	"Truncated Option"*	The exercise period is reduced automatically and the options expire without cancellation if the stock price falls below a predetermined level.	The truncated option is an ESO with a repricing feature imbedded in the contract *ex ante*. Hence, the truncated options are subject to variable award accounting.
(4)	"New grants"	Hand out more options at a lower exercise price while leaving underwater options outstanding.	In April 2000, Microsoft granted a total of 70 million options with a strike price of $66.63 to its 34,000 employees. Shareholders' concern is the potential double dilution.
(5)	"New shares"	Grant certain amounts of restricted stocks while leaving underwater options outstanding.	Shareholders' concern is the potential double dilution.
(6)	"Share Swap"	Grant restricted stock of like value in exchange for the submission of underwater options.	Underwater options are worthless and granting restricted stocks dilutes existing shareholders' benefits.

* For details, see "Redesigning Options: One Size Doesn't Fit All," by Steven E. Hall, the Managing Director for Pearl Meyer & Partners, Inc.

Table 2: The agent's terminal wealth if the agent holds and cashes in his/her options until t = 3.

This table facilitates the agent's choice of actions (or level of efforts) at t = 2 to maximize his/her expected terminal utility. Given one of the repricing alternatives considered occurs at node L, this table shows the agent's wealth at t = 3 (denoted as $w_{t=3}$) if the agent holds and cashes in his/her options until the terminal date (t = 3) to begin our backward induction analysis. Let α be the number of call options (each with a strike of unity) awarded to the agent at time 0, and t_c is the personal tax rate.

Agent's Wealth[1] ($w_{i,t=3}$)	Repricing Alternatives at node L			
	No Repricing (NR)[2]	Traditional Repricing (TR)[3]	Delayed Repricing (DR)[4]	Advanced Repricing (AR)[5]
$w_{1,t=3}$	$\alpha(H^3-1)(1-t_c)$	$\alpha(H^3-1)(1-t_c)$	$\alpha(H^3-1)(1-t_c)$	$\alpha(H^3-1)(1-t_c)$
$w_{2,t=3}$	$\max[0, \alpha(H^2L-1)(1-t_c)]$	$\max[0, \alpha(H^2L-1)(1-t_c)]$	$\max[0, \alpha(H^2L-1)(1-t_c)]$	$\max[0, \alpha(H^2L-1)(1-t_c)]$
$w_{3,t=3}$	$\max[0, \alpha(H^2L-1)(1-t_c)]$	$\max[0, \alpha(H^2L-1)(1-t_c)]$	$\max[0, \alpha(H^2L-1)(1-t_c)]$	$\max[0, \alpha(H^2L-1)(1-t_c)]$
$w_{4,t=3}$	0	0	0	0
	The agent's wealth above is the same for every repricing policy implemented at node L			
$w_{5,t=3}$	$\max[0, \alpha(H^2L-1)(1-t_c)]$	$\alpha(H^2L-L)(1-t_c)$	$\alpha(H^2L-HL)(1-t_c)$	$\alpha(H^2L-L)(1-t_c)+$ $\max[0, \alpha(H^2L-1)(1-t_c)]$
$w_{6,t=3}$	0	0	0	0
$w_{7,t=3}$	0	0	$\alpha(HL^2-L^2)(1-t_c)$	0
$w_{8,t=3}$	0	0	0	0

[1] $w_{i,t=3}$ is the agent's wealth at the terminal node i. See Figure 1 for the corresponding paths leading to each of eight terminal nodes.

[2] If no repricing (NR) occurs at node L, the underwater options are worthless at nodes HL- and HL^2 because $HL^2 < HL < 1$.

[3] If traditional repricing (TR) occurs at node L, the agent may choose to exercise his/her options at node HL- because repriced options (with a strike price of L) are in-the-money.

[4] If delayed repricing (DR) occurs at node L, the underwater options will be cancelled and replaced by a new grant at node HL- or L^2.

[5] If advanced repricing (AR) occurs at node L, new a options will be granted immediately at a strike price of L while keeping old options until t = 3. Hence, the agent may exercise his/her new options at node HL- and keep the old options until the terminal date.

Table 3: The agent's terminal wealth if the agent holds and cashes in his/her options until t = 2.

This table facilitates the agent's choice of exercise strategies (hold or exercise) at t = 2 to maximize his/her expected terminal utility. Given one of the repricing alternatives occurs at node L, this table shows the agent's wealth at t = 3 (denoted as $w_{t=3}$) if the agent holds and cashes in his/her options until the terminal date (t = 2) to continue our backward induction analysis. Let α be the number of call options (each with a strike of unity) awarded to the agent at time 0, and t_c is the personal tax rate.

If options exercised and cashed in at t = 2	Repricing Alternatives at node L			
	No Repricing (NR) [1]	Traditional Repricing (TR) [2]	Delayed Repricing (DR) [3]	Advanced Repricing (AR) [4]
	Agent's Terminal Wealth ($w_{t=3}$) if options are exercised at t = 2			
H^2	$\alpha(H^2-1)(1-t_c)$	$\alpha(H^2-1)(1-t_c)$	$\alpha(H^2-1)(1-t_c)$	$\alpha(H^2-1)(1-t_c)$
HL+	HOLD [5]	HOLD	HOLD	HOLD
HL-	HOLD	$\alpha(HL-L)(1-t_c)$	HOLD	$\alpha(HL-L)(1-t_c)$ + HOLD [4]
L^2	HOLD	HOLD	HOLD	HOLD [6]

[1] If no repricing (NR) occurs at node L, the underwater options are worthless at nodes HL- and HL^2 because $HL^2 < HL < 1$.

[2] If traditional repricing (TR) occurs at node L, the agent may choose to exercise his/her options at node HL- because repriced options (with a strike price of L) are in-the-money.

[3] If delayed repricing (DR) occurs at node L, the underwater options will be cancelled and replaced by a new grant at node HL- or L^2.

[4] If advanced repricing (AR) occurs at node L, new a options will be granted immediately at a strike price of L while keeping old options until t = 3. Hence, the agent may exercise his/her new options at node HL- and keep the old options until the terminal date.

[5] The agent chooses to hold because the options are worthless at nodes HL+ (Note that $HL < 1$).

[6] If advanced repricing (AR) occurs at node L, the agent's new and old options will end up worthless at node HL^2 because $HL^2 < L < 1$.

Table 4: The principal's terminal share value ($f_{t=3}$) if the agent holds and cashes in his/her options until t = 3.

Given one of the repricing alternatives occurs at node L, this table lists the principal's terminal share value ($f_{t=3}$) if the agent hold and cashes in his/her options until **t = 3.** Note that $f_{t=3}$ depends on the agent's exercise strategy. If exercised, the number of outstanding shares increases. If not, the principal's share value ($f_{t=3}$) will be the same as the firm value ($FV_{t=3}$) plus accounting charges if applied. Let α be the number of call options (each with a strike of unity) awarded to the agent at time 0, and π_c is the corporate tax rate.

Principal's Share Value[1] ($f_{i,t=3}$)	Repricing Alternatives at node L: No Repricing (NR)[2]	Traditional Repricing (TR)[3]	Delayed Repricing (DR)[4]	Advanced Repricing (AR)[5]
$f_{1,t=3}$	$\frac{H^3 + \alpha + \pi_c \alpha (H^3 - 1)}{1 + \alpha}$	$\frac{H^3 + \alpha + \pi_c \alpha (H^3 - 1)}{1 + \alpha}$	$\frac{H^3 + \alpha + \pi_c \alpha (H^3 - 1)}{1 + \alpha}$	$\frac{H^3 + \alpha + \pi_c \alpha (H^3 - 1)}{1 + \alpha}$
$f_{2,t=3}$	$\frac{H^2L + \alpha + \pi_c \alpha (H^2L - 1)}{1 + \alpha}$ or H^2L (if $H^2L < 1$)	$\frac{H^2L + \alpha + \pi_c \alpha (H^2L - 1)}{1 + \alpha}$ or H^2L (if $H^2L < 1$)	$\frac{H^2L + \alpha + \pi_c \alpha (H^2L - 1)}{1 + \alpha}$ or H^2L (if $H^2L < 1$)	$\frac{H^2L + \alpha + \pi_c \alpha (H^2L - 1)}{1 + \alpha}$ or H^2L (if $H^2L < 1$)
$f_{3,t=3}$	$\frac{H^2L + \alpha + \pi_c \alpha (H^2L - 1)}{1 + \alpha}$ or H^2L (if $H^2L < 1$)	$\frac{H^2L + \alpha + \pi_c \alpha (H^2L - 1)}{1 + \alpha}$ or H^2L (if $H^2L < 1$)	$\frac{H^2L + \alpha + \pi_c \alpha (H^2L - 1)}{1 + \alpha}$ or H^2L (if $H^2L < 1$)	$\frac{H^2L + \alpha + \pi_c \alpha (H^2L - 1)}{1 + \alpha}$ or H^2L (if $H^2L < 1$)
$f_{4,t=3}$	HL^2	HL^2	HL^2	HL^2
	The principal's share value above is the same for every repricing policy implemented at node L.			
$f_{5,t=3}$	$\frac{H^2L + \alpha + \pi_c \alpha (H^2L - 1)}{1 + \alpha}$ or H^2L (if $H^2L < 1$)	$\frac{H^2L + \alpha L + \pi_c \alpha [(1-L) + (H^2L - L)]}{1 + \alpha}$	$\frac{H^2L + \alpha (HL) + \pi_c \alpha [H^2L - HL]}{1 + \alpha}$	$\frac{H^2L + \alpha (L+1) + \pi_c \alpha [2H^2L - L - 1]}{1 + 2\alpha}$ or $\frac{H^2L + \alpha L + \pi_c \alpha (H^2L - L)}{1 + \alpha}$
$f_{6,t=3}$	HL^2	$HL^2 + \pi_c \alpha [(1-L) + (HL^2 - L)]$	HL^2	HL^2
$f_{7,t=3}$	HL^2	$HL^2 + \pi_c \alpha [(1-L) + (HL^2 - L)]$	$\frac{HL^2 + \alpha L^2 + \pi_c \alpha [HL^2 - L^2]}{1 + \alpha}$	HL^2
$f_{8,t=3}$	L^3	$L^3 + \pi_c \alpha [(1-L) + (L^3 - L)]$	L^3	L^3

1. $f_{i,\,t=3}$ is the principal's share value at the terminal node *i*. See Figure 1 for the corresponding paths leading to each of eight terminal nodes.

2. If no repricing (NR) occurs at node L, the underwater options are worthless at nodes HL- and HL^2 because $HL^2 < HL < 1$.

3. If traditional repricing (TR) occurs at node L, the agent may choose to exercise his/her options at node HL- because repriced options (with a strike price of L) are in-the-money.

4. If delayed repricing (DR) occurs at node L, the underwater options will be cancelled and replaced (at least 6 months later) by a new grant at node HL- or L^2.

5. If advanced repricing (AR) occurs at node L, new *a* options will be granted immediately at a strike price of L while keeping old options until t = 3. Hence, the agent may exercise his/her new options at node HL- and keep the old options until the terminal date.

Table 5: The principal's terminal share value ($f_{t=3}$) if the agent holds and cashes in his/her options until t = 2.

Given one of the repricing alternatives occurs at node L, this table lists the principal's terminal share value ($f_{t=3}$) if the agent hold and cashes in his/her options until **t = 2.** Note that $f_{t=3}$ depends on the agent's exercise strategy. If exercised, the number of outstanding shares increases. If not, the principal's share value ($f_{t=3}$) will be the same as the firm value ($FV_{t=3}$) plus accounting charges if applied. Let α be the number of call options (each with a strike of unity) awarded to the agent at time 0, and π_c is the corporate tax rate.

Principal's Share Value[1] ($f_{i,t=3}$)	Repricing Alternatives at node L: No Repricing (NR)[2]	Traditional Repricing (TR)[3]	Delayed Repricing (DR)[4]	Advanced Repricing (AR)[5]
$f_{1,t=3}$	$\frac{H^3 + \alpha + \pi_c \alpha (H^2 - 1)}{1 + \alpha}$	$\frac{H^3 + \alpha + \pi_c \alpha (H^2 - 1)}{1 + \alpha}$	$\frac{H^3 + \alpha + \pi_c \alpha (H^2 - 1)}{1 + \alpha}$	$\frac{H^3 + \alpha + \pi_c \alpha (H^2 - 1)}{1 + \alpha}$
$f_{2,t=3}$	$\frac{H^2L + \alpha + \pi_c \alpha (H^2 - 1)}{1 + \alpha}$	$\frac{H^2L + \alpha + \pi_c \alpha (H^2 - 1)}{1 + \alpha}$	$\frac{H^2L + \alpha + \pi_c \alpha (H^2 - 1)}{1 + \alpha}$	$\frac{H^2L + \alpha + \pi_c \alpha (H^2 - 1)}{1 + \alpha}$
$f_{3,t=3}$	N/A[6]	N/A	N/A	N/A
$f_{4,t=3}$	N/A[6]	N/A	N/A	N/A
	The principal's share value above is the same for every repricing pocily implemented at node L			
$f_{5,t=3}$	N/A[6]	$\frac{H^2L + \alpha L + \pi_c \alpha [(1-L) + (HL-L)]}{1 + \alpha}$	N/A	$\frac{H^2L + \alpha(L+1) + \pi_c \alpha [(H^2L - 1) + (HL-L)]}{1 + 2\alpha}$ or $\frac{H^2L + \alpha L + \pi_c \alpha (HL-L)}{1 + \alpha}$[7]
$f_{6,t=3}$	N/A[6]	$\frac{HL^2 + \alpha L + \pi_c \alpha [(1-L) + (HL-L)]}{1 + \alpha}$	N/A	$\frac{HL^2 + \alpha L + \pi_c \alpha (HL-L)}{1 + \alpha}$
$f_{7,t=3}$	N/A	N/A	N/A	N/A
$f_{8,t=3}$	N/A	N/A	N/A	N/A

[1] $f_{i,t=3}$ is the principal's share value at the terminal node *i*. See Figure 1 for the corresponding paths leading to each of eight terminal nodes.

[2] If no repricing (NR) occurs at node L, the underwater options are worthless at nodes HL- and HL^2 because $HL^2 < HL < 1$.

[3] If traditional repricing (TR) occurs at node L, the agent may choose to exercise his/her options at node HL- because repriced options (with a strike price of L) are in-the-money.

[4] If delayed repricing (DR) occurs at node L, the underwater options will be cancelled and replaced (at least 6 months later) by a new grant at node HL- or L^2.

[5] If advanced repricing (AR) occurs at node L, new α options will be granted immediately at a strike price of L while keeping old options until t = 3. Hence, the agent may exercise his/her new options at node HL- and keep the old options until the terminal date.

[6] The agent will not exercise his/her options at node HL+ or HL- because HL < 1.

[7] If $H^2L > 1$, the agent may exercise his/her old options at node H^2L while exercising new options at node HL-. Otherwise, only new options (with a strike price of L) can be exercised at node HL-.

<u>Table 6</u>: The agent's chosen actions and exercise strategies – An Example

There are four repricing strategies under consideration: no-repricing (NR), traditional repricing (TR), delayed repricing (DR), and advanced repricing (AR). Given a = 0.3 , k = 0.3, and u = 0.4, the following tables show the agent's chosen actions (a_x's) and exercise strategies (E_X's) at the indicated nodes X's. g is the coefficient of relative risk aversion. U_0 is the agent's expected utility and V_0 is the principal's expected payoff at t = 0. Note that a's are within [0, 0.8] in this case. The tax rate is assumed to be 0.34.

(A) When $\gamma = 0$ (risk neutral) :

Nodes	Agent's actions (a_x's)				Exercise Strategies (E_x's)			
X's	NR	TR	DR	AR	NR	TR	DR	AR
H^2	0	0	0	0	**1**	**1**	**1**	**1**
HL+	0.1162	0.1162	0.1162	0.1162	0	0	0	0
HL-	0.1162	0	**0.2218**	0.4963	0	**1**	0	0
L^2	0	0	**0.09504**	0	0	0	0	0
H	0.6269	0.6269	0.6269	0.6269	0	0	0	0
L	0.0067	0.1584	**0.0201**	0.1232	0	0	0	0
I	0.2032	0.1907	0.1985	0.1956	0	0	0	0
U_0	0.0062	0.0092	0.0073	0.0080	0.0062	0.0092	0.0073	0.0080
V_0	0.3722	0.4080	0.3934	0.4215	0.3722	0.4080	0.3934	0.4215

(B) When $\gamma = 0.5$:

Nodes	Agent's actions (a_x's)				Exercise Strategies (E_x's)			
X's	NR	TR	DR	AR	NR	TR	DR	AR
H^2	0.8	0.8	0.8	0.8	0	0	0	0
HL+	0.8	0.8	0.8	0.8	0	0	0	0
HL-	0.8	0.8	0.8	**0**	0	0	0	**1**
L^2	**0**	0	**0.8**	0	0	0	0	0
H	0.8	0.8	0.8	0.8	0	0	0	0
L	**0.676**	**0.8**	**0.475**	**0.8**	0	0	0	0
I	0.8	0.8	0.8	0.8	0	0	0	0
U_0	0.4614	0.4996	0.4893	0.5307	0.4614	0.4996	0.4893	0.5307
V_0	**1.7311**	1.7484	**1.7194**	**1.6751**	1.7311	1.7484	1.7194	1.6751

(C) When $\gamma = 0.9$:

Nodes	Agent's actions (a_x's)				Exercise Strategies (E_x's)			
X's	NR	TR	DR	AR	NR	TR	DR	AR
H^2	0.8	0.8	0.8	0.8	0	0	0	0
HL+	0.8	0.8	0.8	0.8	0	0	0	0
HL-	**0.8**	**0**	**0.8**	**0**	0	**1**	0	**1**
L^2	**0**	**0**	**0.8**	**0**	0	0	0	0
H	0.8	0.8	0.8	0.8	0	0	0	0
L	0.8	0.8	0.8	0.8	0	0	0	0
I	0.8	0.8	0.8	**0**	0	0	0	0
U_0	7.0644	7.3446	7.3459	10.3013	7.0644	7.3446	7.3459	10.3013
V_0	1.7511	1.6802	1.7565	0.4792	1.7511	1.6802	1.7565	0.4792

Table 7: Measure of the Incentive Provided by Each Repricing Strategy – An Example.

There are four repricing strategies under consideration: no-repricing (NR), traditional repricing (TR), delayed repricing (DR), and advanced repricing (AR). Given $\alpha = 0.3$, $k = 0.3$, and $u = 0.4$, the following tables show the incentive measure (defined as w_0/V_0) provided by TR, DR, and AR while comparing to no-repricing (NR). Note that w_0 is the agent's equivalent wealth at $t = 0$, which is derived from

$$U_0 = w_o^{(1-\gamma)}/(1-\gamma)$$

where γ is the coefficient of relative risk aversion and U_0 is the agent's expected utility at $t = 0$. V_0 is the principal's expected payoff at $t = 0$. Note that a's are within [0, 0.8] in this case. The tax rate is assumed to be 0.34.

(A) When $\gamma = 0$ (risk neutral) :

	NR	TR	DR	AR
U_0	0.0062	**0.0092**	0.0073	0.0080
w_0	0.0062	0.0092	0.0073	0.0080
V_0	0.3722	0.4080	0.3934	**0.4215**
$\Delta w_0/\Delta V_0$	--	**0.0841**	0.0531	0.0368
$\Delta V_0/\Delta w_0$	--	11.8843	18.8291	**27.1485**

(B) When $\gamma = 0.5$:

	NR	TR	DR	AR
U_0	0.4614	0.4996	0.4893	0.5307
w_0	0.0532	0.0624	0.0599	0.0704
V_0	1.7311	1.7484	1.7194	1.6751
$\Delta w_0/\Delta V_0$	--	**0.5311**	-0.5641	-0.3068
$\Delta V_0/\Delta w_0$	--	**1.8828**	-1.7727	-3.2595

(C) When $\gamma = 0.9$:

	NR	TR	DR	AR
U_0	7.0644	7.3446	7.3459	10.3013
w_0	0.0310	0.0457	0.0458	1.3456
V_0	1.7511	1.6802	1.7565	0.4792
$\Delta w_0/\Delta V_0$	--	-0.2074	**2.7406**	-1.0336
$\Delta V_0/\Delta w_0$	--	-4.8207	**0.3649**	-0.9675

Table 8: The agent's expected actions and exercise strategies

There are four repricing strategies under consideration: no-repricing (NR), traditional repricing (TR), delayed repricing (DR), and advanced repricing (AR). Averaging over the space of {α, u, γ, k}, the following tables show the agent's expected actions (a_x's) and exercise strategies (E_x's) at theindicated nodes X's. Note that α is the initial option grant, γ is the coefficient of relative risk aversion, u is the variability of firm value in subsequent period, and k is the coefficient in the agent's disutility function ($= 0.5{*}ka_x^2$) resulting from the agent's action (a_x). Note thata_x's are within [0, 0.8], □'s within [0.1, 1], u's within [0.1, 0.9], γ's within [0, 0.9], and k within [0.1, 1]. The tax rate is assumed to be 0.34. Note that w_0 is the agent's equivalent wealth at t = 0, which is derived from $U_0 = w_o^{(1-\gamma)}/(1-\gamma)$, where U_0 is the agent's expected utility at t =0 and V_0 is the principal's expected payoff at t = 0.

Nodes	Agent's actions (a_x's)				Exercise Strategies (E_x's)			
X's	NR	TR	DR	AR	NR	TR	DR	AR
H^2	0.3688	0.3688	0.3688	0.3688	52.68%	52.68%	52.68%	52.68%
HL+	0.3394	0.3394	0.3394	0.3394	0	0	0	0
HL-	0.3394	0.1699	**0.6055**	0.2743	0	**78.75%**	0	**63.56%**
L^2	0	0	**0.4880**	0	0	0	0	0
H	0.7175	0.7175	0.7175	0.7175	1.22%	1.22%	1.22%	1.22%
L	**0.2501**	0.5680	**0.3629**	0.5608	0	0	0	0
I	0.6452	0.6245	0.6319	**0.4643**	0	0	0	0
U_0	1.3613	1.4805	**1.4698**	**1.7567**				
	(1.9322)*	(2.1026)	(2.1012)	(2.7202)				
w_0	0.1359	0.1524	0.1490	0.2772				
	(0.2230)	(0.2288)	(0.2265)	(0.5240)				
V_0	1.2665	1.2783	**1.2841**	**1.1582**				
	(0.7267)	(0.7383)	(0.7304)	(0.7734)				
$\Delta w_0/\Delta V_0$	--	**1.4020**	0.7450	-1.3039				

* The number in parentheses is the standard error of the variable above.

Table 9: The Optimal Repricing Policy under TR (Traditional Repricing)

The optimal repricing policy (C*) combined with a_l* specifies how deeply the options are under water before repricing takes place. Given a repricing strategy (TR, DR, or AR), k, α, and γ, we simultaneously determine (a_l*, C*) in one of the propositions as described below while drawing u's from a uniform distribution between (0,1). We average the statistics as indicated over 5,000 random draws of u's given (k, α, γ) and then over the parameter space of (k, α, γ).

(A): Risk Neutral (γ = 0)

		TR (Traditional Repricing)						
Propositions	(a_l^* , C^*)	% occurrence	a_l^*	C^*	k	α	γ	u
Prop. 1	(0, 1)	0%	0	1.00	0	0	0	0
Prop. 2	(0, 0)	0%	0	0	0	0	0	0
Prop. 3	($\bar{a}$, 1)	0%	0.80	1.00	0	0	0	0
Prop. 4	($\bar{a}$, 0)	**36.94%**	0.80	0	0.4045	0.6947	0	0.7116
Prop. 5	((U_h - $U_l^{C^*}$)/k, A)	0.78%	0.55	0.46	0.3619	0.7103	0	0.3307
Prop. 6	((U_h - U_l^{NR})/k, 1)	**10.98%**	0.00	1.00	0.6844	0.5316	0	0.0677
Prop. 7	((U_h - U_l^R)/k, 0)	**51.30%**	0.19	0	0.6289	0.4473	0	0.4425
Weighted Average		--	**0.40**	**0.11**	0.55	0.55	0	0.50

(B): Risk Adverse (γ > 0)

Propositions	(a_l^* , C^*)	% occurrence	a_l^*	C^*	k	α	γ	u
Prop. 1	(0, 1)	0%	0	1.00	0	0	0	0
Prop. 2	(0, 0)	0%	0	0	0	0	0	0
Prop. 3	($\bar{a}$, 1)	28.24%	0.80	1.00	0.4782	0.5798	**0.72**	0.3126
Prop. 4	($\bar{a}$, 0)	**41.36%**	0.80	0	0.4952	**0.6063**	0.49	**0.7496**
Prop. 5	((U_h - $U_l^{C^*}$)/k, A)	1.80%	0.41	0.47	**0.6639**	0.5686	0.41	0.2592
Prop. 6	((U_h - U_l^{NR})/k, 1)	1.74%	**0.09**	1.00	**0.7221**	0.5447	**0.23**	0.0400
Prop. 7	((U_h - U_l^R)/k, 0)	**26.86%**	0.28	0	0.6911	0.4310	0.30	**0.3601**
Weighted Average		--	**0.64**	**0.31**	0.55	0.55	0.50	0.50

a_l^*: the agent's action (or level of effort) at the initial node I under the optimal repricing policy C*.

k : the coefficient in the disutility function (= $0.5*ka^2$) resulting from the agent's effort (a).

α : the initial option grant.

γ : the coefficient of the agent's risk aversion.

u : the variability of firm value in the subsequent period. Note that H = 1+u; L = 1-u.

$$A = \frac{(U_l^{NR} - U_l^R)(V_h - V_l^R) + (V_l^{NR} - V_l^R)(U_h - k - U_l^R)}{2\ (U_l^{NR} - U_l^R)(V_l^{NR} - V_l^R)}$$

Table 10: The Optimal Repricing Policy under DR (Delayed Repricing)

The optimal repricing policy (C*) combined with a_i* specifies how deeply the options are under water before repricing takes place. Given a repricing strategy (TR, DR, or AR), k, α, and γ, we simultaneously determine (a_i^*, C^*) in one of the propositions as described below while drawing u's from a uniform distribution between (0,1). We average the statistics as indicated over 5,000 random draws of u's given (k, α, γ) and then over the parameter space of (k, α, γ).

(A): Risk Neutral ($\gamma = 0$)

		DR (Delayed Repricing)						
Propositions	(a_l^*, C^*)	% occurrence	a_l^*	C^*	k	α	γ	u
Prop. 1	(0, 1)	0%	0	1.00	0	0	0	0
Prop. 2	(0, 0)	0%	0	0	0	0	0	0
Prop. 3	$(\bar{a}, 1)$	0%	0.80	1.00	0	0	0	0
Prop. 4	$(\bar{a}, 0)$	**37.30%**	0.80	0	0.4027	0.6931	0	0.7096
Prop. 5	$((U_h - U_l^{C^*})/k, A)$	0.33%	0.57	0.48	0.3471	0.7257	0	0.3162
Prop. 6	$((U_h - U_l^{NR})/k, 1)$	0%	0	1.00	0	0	0	0
Prop. 7	$((U_h - U_l^{R})/k, 0)$	**62.37%**	0.16	0	0.6392	0.4635	0	0.3768
Weighted Average		--	**0.40**	**0.00**	0.55	0.55	0	0.50

(B): Risk Adverse ($\gamma > 0$)

Propositions	(a_l^*, C^*)	% occurrence	a_l^*	C^*	k	α	γ	u
Prop. 1	(0, 1)	0%	0	1.00	0	0	0	0
Prop. 2	(0, 0)	0%	0	0	0	0	0	0
Prop. 3	$(\bar{a}, 1)$	21.69%	0.80	1.00	0.5405	0.6027	**0.71**	0.2906
Prop. 4	$(\bar{a}, 0)$	**48.91%**	0.80	0	0.4684	**0.5925**	0.52	**0.6944**
Prop. 5	$((U_h - U_l^{C^*})/k, A)$	1.20%	0.43	0.47	**0.6626**	0.4832	0.43	0.2916
Prop. 6	$((U_h - U_l^{NR})/k, 1)$	0.33%	**0.73**	1.00	**0.7390**	0.5089	**0.67**	0.0712
Prop. 7	$((U_h - U_l^{R})/k, 0)$	**27.88%**	0.26	0	0.6934	0.4379	0.29	**0.3360**
Weighted Average		--	**0.65**	**0.23**	0.55	0.55	0.50	0.50

a_l^*: the agent's action (or level of effort) at the initial node I under the optimal repricing policy C*.

k : the coefficient in the disutility function ($= 0.5*ka^2$) resulting from the agent's effort (a).

α : the initial option grant.

γ : the coefficient of the agent's risk aversion.

u : the variability of firm value in the subsequent period. Note that H = 1+u; L = 1-u.

$$A = \frac{(U_l^{NR} - U_l^R)(V_h - V_l^R) + (V_l^{NR} - V_l^R)(U_h - k - U_l^R)}{2\,(U_l^{NR} - U_l^R)(V_l^{NR} - V_l^R)}$$

Table 11: The Optimal Repricing Policy under AR (Advanced Repricing)

The optimal repricing policy (C*) combined with a_i* specifies how deeply the options are under water before repricing takes place. Given a repricing strategy (TR, DR, or AR), k, α, and γ, we simultaneously determine (a_i*, C*) in one of the propositions as described below while drawing u's from a uniform distribution between (0,1). We average the statistics as indicated over 5,000 random draws of u's given (k, α, γ) and then over the parameter space of (k, α, γ).

(A): Risk Neutral ($\gamma = 0$)

		AR (Advanced Repricing)						
Propositions	(a_I^*, C^*)	% occurrence	a_I^*	C^*	k	α	γ	u
Prop. 1	(0, 1)	0%	0	1.00	0	0	0	0
Prop. 2	(0, 0)	0%	0	0	0	0	0	0
Prop. 3	$(\bar{a}, 1)$	0%	0.80	1.00	0	0	0	0
Prop. 4	$(\bar{a}, 0)$	**35.95%**	0.80	0	0.4094	0.6945	0	0.7209
Prop. 5	$((U_h - U_l^{C^*})/k, A)$	1.35%	0.57	0.45	0.2896	0.7123	0	0.2874
Prop. 6	$((U_h - U_l^{NR})/k, 1)$	0%	0	1.00	0	0	0	0
Prop. 7	$((U_h - U_l^{R})/k, 0)$	**62.70%**	0.16	0	0.6362	0.4636	0	0.3760
Weighted Average		--	**0.39**	**0.01**	0.55	0.55	0	0.50

(B): Risk Adverse ($\gamma > 0$)

Propositions	(a_I^*, C^*)	% occurrence	a_I^*	C^*	k	α	γ	u
Prop. 1	(0, 1)	0%	0	1.00	0	0	0	0
Prop. 2	(0, 0)	**0.16%**	0	0	**0.7898**	0.4600	0.69	0.0368
Prop. 3	$(\bar{a}, 1)$	29.72%	0.80	1.00	0.4766	0.5821	**0.71**	0.3174
Prop. 4	$(\bar{a}, 0)$	**39.46%**	0.80	0	0.5015	**0.6026**	0.50	**0.7676**
Prop. 5	$((U_h - U_l^{C^*})/k, A)$	2.00%	0.41	0.47	**0.6048**	0.5814	0.39	0.2360
Prop. 6	$((U_h - U_l^{NR})/k, 1)$	0.23%	**0.74**	1.00	**0.7708**	0.3535	**0.69**	0.0910
Prop. 7	$((U_h - U_l^{R})/k, 0)$	**28.44%**	0.24	0	0.6870	0.4434	0.29	**0.3428**
Weighted Average		--	**0.63**	**0.31**	0.55	0.55	0.50	0.50

a_I^*: the agent's action (or level of effort) at the initial node I under the optimal repricing policy C*.

k : the coefficient in the disutility function (= $0.5{*}ka^2$) resulting from the agent's effort (a).

α : the initial option grant.

u : the variability of firm value in the subsequent period. Note that H = 1+u; L = 1-u.

$$A = \frac{(U_l^{NR} - U_l^{R})(V_h - V_l^{R}) + (V_l^{NR} - V_l^{R})(U_h - k - U_l^{R})}{2\,(U_l^{NR} - U_l^{R})(V_l^{NR} - V_l^{R})}$$

Table 12: Estimated Agency Costs [1]

This table shows the estimated agency costs if the agent is compensated with a stock options only. We compute the mean V_0 (the principal's expected payoff at t = 0) over the parameter space of {α, u, γ, k}. Recall that α is the initial option grant, γ is the coefficient of relative risk aversion, u is the variability of firm value in subsequent periods, and k is the coefficient in the agent's disutility function (= 0.5^*ka^2) resulting from the agent's action (a). Note that a's are set within [0, 0.8], u's within [0.1, 0.9], γ's within [0.1, 0.9], and k's within [0.1, 1]. The tax rate is assumed to be 0.34.

(A) The principal is risk neutral ($\gamma = 0$).[2]

Organization / Strategy	Principal's Expected Payoff (Mean V_0) [3]	Estimated Agency Costs		
		$	%	Min / Max [4]
Sole-proprietorship	1.7825	–	–	–
Principal-Agent / NR	1.2784	-0.5041	-28.28%	-52.53% / -19.62%
Principal-Agent / TR	1.2879	-0.4946	-27.75%	-52.96% / -18.37%
Principal-Agent / DR	1.2965	-0.4860	**-27.26%**	**-51.78% / -18.46%**
Principal-Agent / AR	1.1553	-0.6272	-35.19%	-59.49% / -26.22%

(B) The principal is risk adverse ($0 < \gamma < 1$).

Organization / Strategy	Principal's Expected Payoff (Mean V_0) [3]	Estimated Agency Costs		
		$	%	Min / Max [4]
Sole-proprietorship	1.2240	–	–	–
Principal-Agent / NR	1.2784	0.0544	+ 4.44%	-30.87% / +17.05%
Principal-Agent / TR	1.2879	0.0639	+ 5.22%	-31.50% / +18.86%
Principal-Agent / DR	1.2965	0.0725	**+ 5.92%**	-29.78% / +18.74%
Principal-Agent / AR	1.1553	-0.0688	**- 5.62%**	-41.01% / + 7.45%

[1] The agency cost is defined as the difference in expected initial payoffs between each principal-agent case with different strategy and the base case of sole-proprietorship.

[2] We assume that the sole owner-manager has the same disutility function as the agent in the principal-agent framework.

[3] The mean expected payoff is the principal's average expected initial payoff while integrating over the parameter space of {α, u, γ, k}.

[4] The minimal / maximal agency cost is computed given different a's while averaging the principal's expected initial payoff over the parameter space of {u, γ, k}. The agency costs monotonically decrease as α increases.

APPENDICES

Appendix A

Equilibrium under the Strategies Indicated

We follow the proofs in the Appendix A of Acharya, John, and Sundaram (2000) (hereafter AJS). One key difference is that we assume $p(\mathrm{H}) = p(a) = q\ m + (1-q\ )a$ instead of $p(\mathrm{H}) = p(a) = a$, where m, a, and $q \in [0,1]$. Another difference is in the terminal payoff structures for both principal and agent because of the dilution effect and the tax effect of new accounting rules associated with repricing. Those rules took effect in June 2000 and retroactive to December 15, 1998. The strategy of rescission is not considered by AJS. The payoff structures for each strategy under consideration are listed in Table 1 through Table 4.

A.1. Equilibrium under Do-nothing

Let α be the number of call options (each with a strike of unity) awarded to the agent at time 0. The terminal payoff structures for both principal and agent are listed in Table 1 and Table 2, respectively. Contingent upon reaching the node H, the agent solves

$$\max_{a_h \in [0,1]} \{ p(H)(\alpha(f_{hh} - 1)) + p(L)0 - \frac{1}{2} k a_h^2 \}$$

where $p(\mathrm{H}) = p(a_h) = qm + (1-q\ )\ a_h = 1 - p(\mathrm{L})$, and

$$f_{hh} = \frac{\mathrm{HH} + \alpha + \pi_c \alpha[\mathrm{HH} - 1]}{1+\alpha} \quad (\pi_c\text{: corporate tax rate})$$

This has the solution

$$a_h(\alpha) = \begin{cases} \alpha(1\text{-}q)(f_{hh}\text{-}1)/k & \text{if } \alpha < k/[(1\text{-}q)(f_{hh}\text{-}1)] \\ 1 & \text{otherwise} \end{cases} \tag{A1}$$

Thus, the agent's and principal's continuation payoffs $U_h(\alpha)$ and $V_h(\alpha)$ from the node H are given by

$$U_h(\alpha) = [p(a_h(\alpha))][\alpha(f_{hh}\text{-}1)] - \frac{1}{2}k[a_h(\alpha)]^2 \tag{A2}$$

and

$$V_h(\alpha) = [p(a_h(\alpha))]f_{hh} + [1 - p(a_h(\alpha))]f_{hl}. \tag{A3}$$

At node L, the options are guaranteed to finish out of the money, so we have $a_l = U_l = 0$ and

$$V_l = (qm)f_{lh} + (1\text{-}qm)f_{ll}.$$

At the initial node, now, the agent solves

$$\max_{a \in [0,1]} \{ p(a)U_h(\alpha) - \frac{1}{2}ka^2 \}$$

where $p(a) = qm + (1 - q)\,a = 1\text{-}p(\text{L})$.

Hence, the optimal initial action for the agent is

$$a(\alpha) = \begin{cases} (1 - q)\,U_h(\alpha)/k & \text{if } U_h(\alpha) < k/(1\text{-}q) \\ 1 & \text{otherwise} \end{cases} \tag{A4}$$

Given the agent's optimal response ((A1), (A2), (A3) and (A4)) to an initial offer of α, the principal now chooses α to maximize his/her initial expected payoff (V):

$$\max_{\alpha \in [0,1]} \{[p(a(\alpha))]V_h(\alpha) + [1 - p(a(\alpha))]V_l\} \tag{A5}$$

Our goal is to solve (A5). To simplify the notation, we will suppress the dependence on α in the following discussion. There are four possibilities that could be induced by α in equilibrium:

(1) $a_h < 1$, $a < 1$, (2) $a_h < 1$, $a = 1$, (3) $a_h = 1$, $a < 1$, and (4) $a_h = a = 1$.

For instance, in case (1), those inequalities can hold only if

$$a_h = \alpha(1-q)(f_{hh}-1)/k \qquad \text{and} \qquad a = (1-q)\,U_h(\alpha)/k$$

Equivalently, for these to hold, α must satisfy

$$\alpha < k/[(1-q)(f_{hh}-1)] \qquad \text{and} \qquad U_h(\alpha) < k/(1-q). \tag{A6}$$

Should α not satisfy both conditions, equilibria of this form evidently do not exist. Otherwise, solving $\partial V/\partial\alpha = 0$ generates a candidate equilibrium solution as long as α satisfies the two inequalities in (A6). We will check these conditions for given specific values of the parameters while simulating the results.

To establish the optimal value of α under the do-nothing strategy, we need to first identify the potential solutions for α's in all cases above. Then we compare the values of the objective function (V) at these solutions (as well as the value when $\alpha = 0$) given any set of values for the parameters u, q, m, π_c and k. Finally, the optimal value of α is the one that maximizes the principal's expected initial payoff (V) as required.

Q.E.D.

A.2. Equilibrium under Repricing

In this section, we will establish equilibria when repricing is possible. To keep our focus on underwater options, we assume that repricing only occurs when the options are out-of-money (e.g., at node L) with a probability of π. When repricing takes place, all existing options (α) are reset at a new exercise price of L, meaning the renewed options are issued at-the-money. To make our model closer to the reality, we also assume that the probability of repricing at node L is $\pi \leq 1$. In addition, the payoffs under repricing for the principal and the agent are listed in Tables 1 and 2, respectively.

The proof, procedure-wise, is analogous to the one under the do-nothing strategy. First, we use superscripts N and R to denote no-repricing and repricing, respectively. For instance, at node L, the agent needs to choose a_l to solve

$$\max_{a_l \in [0,1]} \{\pi U_l^R + (1-\pi)U_l^N\}$$

where $\quad U_l^R = p(a_l)[\alpha(f_{lh} - \mathrm{L})] + (1-p(a_l))[0] - \frac{1}{2}ka_l^2$,

$U_l^N = p(a_l)[0] + (1-p(a_l))[0] - \frac{1}{2}ka_l^2$, $\quad p(a_l) = qm + (1-q)a_l$

$$f_{lh} = \frac{\mathrm{HH}+\alpha\,\mathrm{L}+\mathrm{B_R}}{1+\alpha}, \quad \text{and} \quad \mathrm{B_R} = \pi_c\alpha[(1\text{-L}) + (\text{LH-L})].$$

This has the solution

$$a_l(\alpha) = \begin{cases} \alpha\pi(1\text{-}q)(f_{lh}\text{-L})/k & \text{if } \alpha < k/[\pi(1\text{-}q)(f_{lh}\text{-L})] \\ 1 & \text{otherwise} \end{cases} \tag{A7}$$

However, upon reaching node H, the agent only solves

$$\max_{a_h \in [0,1]} \{p(a_h)[\alpha(f_{hh} - 1)] + [1 - p(a_h)]0 - \frac{1}{2}ka_h^2\}$$

where $\quad f_{hh} = \dfrac{\mathrm{HH}+\alpha+\pi_c\alpha[\mathrm{HH}-1]}{1+\alpha}$,

because the possibility of repricing at node H is ruled out.

This leads to the same solution as that in (A1):

$$a_h(\alpha) = \begin{cases} \alpha(1\text{-}q)(f_{hh}\text{-}1)/k & \text{if } \alpha < k/[(1\text{-}q)(f_{hh}\text{-}1)] \\ 1 & \text{otherwise} \end{cases} \tag{A8}$$

Thus, the agent's continuation payoffs $U_h(\alpha)$ and $U_l(\alpha)$ are given by

$$U_h(\alpha) = [p(a_h(\alpha))][\alpha(f_{hh} - 1)] - \frac{1}{2}k[a_h(\alpha)]^2 \quad \text{(A9)}$$

and

$$U_l(\alpha) = \pi[p(a_l(\alpha))][\alpha(f_{lh} - \text{L})] - \frac{1}{2}k[a_l(\alpha)]^2. \quad \text{(A10)}$$

where $f_{lh} = \dfrac{\text{HH}+\alpha\,\text{L}+\text{B}_\text{R}}{1+\alpha}$, and $\text{B}_\text{R} = \pi_c\alpha[\,(1\text{-L}) + (\text{LH-L})\,]$.

(A10) shows that there is a trade-off of repricing for the agent (Recall that the $U_l(\alpha) = 0$ in the case of do-nothing).

As for the principal, his/her continuation payoffs $V_h(\alpha)$ and $V_l(\alpha)$ are given by

$$\begin{cases} V_h(\alpha) = [p(a_h(\alpha))]f_{hh} + [1 - p(a_h(\alpha))]f_{hl}, & \text{and} \quad \text{(A11)} \\ V_l(\alpha) = \pi\, V_l^R + (1-\pi)\, V_l^N & \text{(A12)} \end{cases}$$

where $f_{hl} = \text{HL}$

$V_l^R = p(a_l)f_{lh} + (1 - p(a_l))f_{ll}$

$V_l^N = p(a_l)[\,\text{LH}\,] + (1 - p(a_l))[\,\text{LL}\,]$, $\qquad p(a_l) = qm + (1-q)a_l$

$f_{lh} = \dfrac{\text{HH}+\alpha\,\text{L}+\text{B}_\text{R}}{1+\alpha}$. and $\text{B}_\text{R} = \pi_c\alpha[\,(1\text{-L}) + (\text{LH-L})\,]$.

$f_{ll} = \text{LL} + \pi_c\alpha[\,(1\text{-L}) + (\text{LL-L})\,]$.

Now, at the initial node, the agent need to solve

$$\max_{a \in [0,1]} \{p(a)U_h(\alpha) + (1 - p(a))U_l(\alpha) - \frac{1}{2}ka^2\}$$

where $p(a) = qm + (1 - q)\, a$.

Hence, the optimal initial action for the agent is

$$a(\alpha) = \begin{cases} (1-q)\,[U_h(\alpha)-U_l(\alpha)\,]\,/\,k & \text{if } U_h(\alpha)-U_l(\alpha) < k/\,(1-q) \\ 1 & \text{otherwise} \end{cases} \qquad \text{A13)}$$

Given the agent's optimal response ((A7), (A8) and (A13)) to an initial offer of α, the principal now chooses α to maximize his/her initial expected payoff:

$$\max_{\alpha \in [0,1]} \{[\,p(a(\alpha))]V_h(\alpha) + [1 - p(a(\alpha))]V_l\} \qquad \text{(A14)}$$

The procedure for solving (A14) is exactly the same as that for solving (A5).

As in the Appendix A.1, we first identify the potential solutions for α's in all possible cases. Then we compare the values of the objective function (V) at these solutions (as well as the value when $\alpha = 0$) given any set of values for the parameters u, q, m, k, π_c and π. Finally, the optimal value of α is the one that maximizes the principal's expected initial payoff (V) as required.

Q.E.D.

A.3. Equilibrium under Rescission

In this section, we will establish equilibria when rescission is possible. In case of rescission, we assume, without loss of generality, the agent exercises the options at node H and the principal will rescind the already-exercised options (or equivalently buys back α shares at a price of unity) at node HL with a probability of $\pi \in [0,1]$. Later, we assume $\pi = u$. Recall that u indicates how deeply the options are under water at the end of Period 1 (for example, L = 1 - u and $u \in (0,1)$). For simplicity, we assume all payoffs are received at the terminal date t = 2.

As a tax-motivated strategy, rescission is designed to rescue employees who would not have sufficient proceeds from selling the stock to pay the tax occurring after option exercise, because of subsequent stock price declines. Hence, we take personal tax into account while analyzing the optimality of rescission. For simplicity, we assume that the agent's personal tax rate is the same as the corporate tax rate (π_c).

The exercise at node H generates a tax liability to the agent of $T = \pi_c \cdot \alpha(H-1)$ and a tax benefit for the principal of same amount, which the company records as a deferred tax asset or a reduction in current taxes payable. The payoffs under rescission for the principal and the agent are listed in Tables 3 and 4, respectively.

The proof, procedure-wise, is analogous to the one under repricing. First, we use superscripts N and R to denote no-rescission and rescission, respectively. For instance, at node H, the agent needs to choose a_h to solve

$$\max_{a_h \in [0,1]} \{\pi U_h^R + (1-\pi) U_h^N\}$$

where $U_h^R = p(a_h)[\alpha f_{hh} - \alpha - \mathrm{T}] + (1-p(a_h))[0] - \frac{1}{2} k a_h^2$,

$U_h^N = p(a_h)[\alpha f_{hh} - \alpha - \mathrm{T}] + (1-p(a_h))[\alpha f_{hl} - \alpha - \mathrm{T}] - \frac{1}{2} k a_h^2$,

$p(a_h) = qm + (1-q)a_h$,

$\mathrm{T} = \pi_c \alpha(\mathrm{H}-1)$ is the tax liability as a result of exercising options at node H.

[Note that T is also the tax benefit for the principal, which the company records as a deferred tax asset or a reduction in current taxes payable.]

$$f_{hh} = \frac{\mathrm{HH}+\alpha+\mathrm{T}}{1+\alpha} \quad \text{and} \quad f_{hl} = \frac{\mathrm{HL}+\alpha+\mathrm{T}}{1+\alpha}.$$

This leads to the following solution

$$a_h(\alpha) = \begin{cases} \min\{1, \frac{1-q}{k}[\alpha(f_{hh}-f_{hl}) + \pi(\alpha f_{hl} - \alpha - \mathrm{T})]\} & \text{if } \alpha > \pi(\alpha+\mathrm{T})/[f_{hh} - (1-\pi) f_{hl}] \\ 0 & \text{otherwise} \end{cases} \quad \text{(A15)}$$

Thus, the agent's continuation payoff $U_h(\alpha)$ at node H is given by

$$U_h(\alpha) = [p(a_h(\alpha))][\alpha f_{hh} - \alpha - \mathrm{T}] + (1-\pi)[1-p(a_h(\alpha))][\alpha f_{hl} - \alpha - \mathrm{T}] - \frac{1}{2} k [a_h(\alpha)]^2 \quad \text{(A16)}$$

At node L, the options are guaranteed to finish out of the money, so we have

$$a_l = U_l = 0 \qquad \text{and} \qquad V_l = (qm)\,\mathrm{LH} + (1\text{-}qm)\,\mathrm{LL}. \tag{A17}$$

As for the principal, his/her continuation payoffs $V_h(\alpha)$ and $V_l(\alpha)$ are given by

$$V_h(\alpha) = p(a_h(\alpha))f_{hh} + [1 - p(a_h(\alpha))]\,[\pi\,(\mathrm{HL} + \pi_c\alpha\,(1\text{-HL})\,) + (1\text{-}\pi)\,f_{hl}] \tag{A18}$$

and $$V_l(\alpha) = p(a_l(\alpha))(\mathrm{LH}) + [1 - p(a_l(\alpha))]\,(\mathrm{LL}) \tag{A19}$$

Hence, the optimal initial action for the agent is

$$a(\alpha) = \arg \max_{a \in [0,1]} \{p(a)U_h(\alpha) - \frac{1}{2}ka^2\}$$

where $p(a) = qm + (1 - q)\,a$.

This leads to the following solution

$$a(\alpha) = \begin{cases} \min\{1,\ (1-q)\ U_h(\alpha)\,/\,k\,\} & \text{if } U_h(\alpha) > 0 \\ 0 & \text{otherwise} \end{cases} \tag{A20}$$

Given the agent's optimal response ((A15), (A17) and (A20)) to an initial offer of α, the principal now chooses α to maximize his/her initial expected payoff:

$$\max_{\alpha \in [0,1]} \{[\,p(a(\alpha))]V_h(\alpha) + [1 - p(a(\alpha))]V_l\} \tag{A21}$$

The procedure for solving (A21) is exactly the same as that for solving (A14). As in the Appendix A.2, we first identify the potential solutions for α's in all possible cases. Then we compare the values of the objective function (V) at these solutions (as well as the value when $\alpha = 0$) given any set of values for the parameters u, q, m, k, π_c and π. Finally, the optimal value of α is the one that maximizes the principal's expected initial payoff (V) as required.

Q.E.D.

Appendix B

Backward Induction Procedure:

Determine the agent's expected actions and exercise strategies in interim periods.

Step 1: Lay out the expected firm value (denoted as FV), the principal's share value (denoted as f), and the agent's wealth (denoted as w) at t = 3 in Figure 1, Table 2, and Table 4, respectively, if the agent holds and cashes in his/her options until t = 3. The dynamics of firm value can be illustrated in Figure 1 as follows:

$$FV_{t+1} = \delta_t \, FV_t \qquad (t = 0, 1, 2)$$

$$F_0 = 1$$

Here δ_0, δ_1, and δ_2 are assumed to be i.i.d. (independent and identically distributed) stochastic variables, taking only the two values H (= 1 + u) and L (=1 - u) with probabilities

$$P(\delta_t = H) = \; p(a_x)$$

$$P(\delta_t = L) = \; 1 - p(a_x)$$

where $p(a_x) = a_x$ and $a_x \in [0, \bar{a}]$ is the agent's action (or level of effort) at node $X \in \{I, H, L, H^2, HL+, HL-, L^2\}$. Note that $\bar{a} < 1$.

Step 2: Determine the agent's actions (or level of effort) at t = 2. The backward induction procedure starts with the nodes at t = 2 (H^2, HL+, HL-, and L^2) where the agent chooses an action to maximize his/her expected terminal utility. For example, given the pair of terminal wealth (w_1 - w_2), we show in Section 3 that the agent will choose an action at node H^2 (a_{hh}),

$$a_{hh} = \begin{cases} 0 & \text{if} \quad U_1 \leq U_2 \\ (U_1 - U_2)/k & \text{if } 0 < (U_1 - U_2) < k\,\bar{a} \\ \bar{a} & \text{if} \quad (U_1 - U_2) \geq k\,\bar{a} \end{cases} \tag{A1}$$

where $U_i = (w_i^{1-\gamma} - 1)/(1-\gamma)$ and γ is the coefficient of relative risk aversion. Note that k is the coefficient in the disutility function ($= \frac{1}{2}ka^2$) resulting from the agent's effort (a).

Step 3: Determine the agent's exercise strategies at t = 2. For instance, the agent will choose an exercise strategy at node H^2 (E_{hh}),

$$E_{hh} = \begin{cases} 1 \text{ (EXERCISE)} & \text{if } {}_{E}U_{hh} > {}_{C}U_{hh} \\ 0 \text{ (HOLD)} & \text{otherwise} \end{cases} \tag{A2}$$

where ${}_{c}U_{hh}$ is the agent's expected continuation utility from the node H^2 given by

$$ {}_{C}U_{hh} = [a_{hh}][U_1] + [1 - a_{hh}][U_2] - \frac{1}{2}k[a_{hh}]^2 \qquad \text{(A3)}$$

and ${}_{E}U_{hh}$ is the agent's expected terminal utility if the agent choose to exercise his/her options at node H^2:

$$ {}_{E}U_{hh} = U(w_{hh}) = (w_{hh}{}^{1-\gamma})/(1-\gamma) \qquad \text{(A4)}$$

$w_{hh} = \alpha(H^2 - 1)(1 - t_c)$ is the agent's terminal wealth if the agent holds and cashes in his/her options at node H^2. See Table 3 for details.

Note that if $E_{hh} = 1$ (or $E_{hl+} = 1$), then $a_{hh} = 0$ (or $a_{hl+} = 0$) and $E_h = 0$. It means that the options cannot be exercised at t = 1 and ${}_{E}U_{hh}$ becomes the agent's expected continuation utility at node H^2 (still denoted as ${}_{C}U_{hh}$ for simplicity).

Step 4: Repeat Steps 2 and 3 until we determine the agent's expected actions (a's) and exercise strategies (E's) at t = 2.

Step 5: Repeat Steps 2,3, and 4 until we determine the agent's expected actions (a's) and exercise strategies (E's) at t = 1, and t = 0.

Step 6: Compute the principal's expected payoff at t = 0 based on the agent's expected actions (*a*'s) and exercise strategies (*E*'s).

Step 7: Repeat Steps 1- 6 for each repricing strategy. The repricing strategies considered in our paper include no repricing (NR), traditional repricing (TR), delayed repricing (DR), and advanced repricing (AR).

Appendix C

Optimal Repricing Policy -- Proof of *Proposition 5*

We propose an optimal repricing policy for each considered repricing strategy (TR, DR, or AR), which specifies how deeply the options are under water at t = 1 before repricing takes place at node L. In other words, given a repricing strategy, the principal sets a triggering point at t = 0 (denoted as C) for repricing, if any, to take place at node L while considering the agent's best response at the initial node I (denoted as a_i) to this policy. Note that we use the backward induction procedure as described in the Appendix B to determine the agent's expected actions and exercise strategies and the principal's expected payoffs from t = 3 to t = 1.

At the initial node I, the end node in the backward induction procedure, the agent will choose an action (a_i) and the principal will set a triggering policy (C) simultaneously. The combination of strategies chosen by both participants determines a payoff for each one. We derive each participant's best response to the predicted strategy of the other, namely (a_i^* , C*), with the necessary and sufficient conditions under which the Nash equilibria hold. This appendix provides the proof for *Proposition 5*. The proofs of other propositions follow a similar procedure.

Proposition 5: If and only if $(U_h - k\,\bar{a} < U_l^C < U_h)$, and $(0 < A < 1)$, where

$$A = \frac{(U_l^{NR} - U_l^R)(V_h - V_l^R) + (V_l^{NR} - V_l^R)(U_h - k - U_l^R)}{2\ (U_l^{NR} - U_l^R)(V_l^{NR} - V_l^R)}, \tag{B1}$$

then
$$\begin{cases} a_i^* = (U_h - U_l^{C*})/k & \text{and} \quad \text{(B2)} \\ C^* = A & \text{(B3)} \end{cases}$$

where
$$U_l^{C*} = C^*\, U_l^{NR} + (1 - C^*)\, U_l^R \tag{B4}$$

Proof:

Let U_l^R (U_l^{NR}) be the agent's expected utility at node L with repricing (no repricing), which is derived from the backward induction procedure mentioned above. Since u is assumed to be uniformly distributed between (0,1), the agent's expected utility at node L given a triggering policy (C) is

$$U_l^C = C\, U_l^{NR} + (1 - C)\, U_l^R \tag{B5}$$

Note that the probability of no repricing at node L is equal to the probability of (C > u), which is equal to C. Hence, the agent solves

$$a_i^* = \arg \max_{a_i \in [0, \bar{a}]} \{ a_i U_h + (1 - a_i) U_l^C) - \frac{1}{2} k a_i^2 \} \tag{B6}$$

where U_h is the agent's expected utility at node H. Then the agent's expected action at the initial node I is

$$a_i^* = \begin{cases} 0 & \text{if} \quad (U_h - U_l^C) \leq 0 \\ (U_h - U_l^C)/k & \text{if} \quad 0 < (U_h - U_l^C) < k\,\bar{a} \\ \bar{a} & \text{if} \quad (U_h - U_l^C) \geq k\,\bar{a} \end{cases} \qquad \text{(B7)}$$

Therefore, the agent's expected utility at t = 0 is

$$U_0^* = a_i^* U_h + (1 - a_i^*) U_l^C - \frac{1}{2} k (a_i^*)^2 \qquad \text{(B8)}$$

Simultaneously, the principal sets C* to maximize his/her expected payoff at t = 0 while expecting the agent to choose a_i^*. Hence,

$$C^* = \arg \max_{C \in [0,1]} V_0^* = \{ a_i^* V_h + (1 - a_i^*) V_l^C \} \qquad \text{(B9)}$$

where V_l^C is the principal's expected payoff at node L given a triggering policy (C), which

$$V_l^C = C\, V_l^{NR} + (1 - C)\, V_l^R . \qquad \text{(B10)}$$

Note that V_l^R (V_l^{NR}) is the principal's expected payoff at node L with repricing (no repricing), which is derived from the backward induction procedure mentioned in Section 3. Then, the principal's expected payoff at t = 0 is

$$V_0^* = a_i^* \ V_h \ + \ (1 - a_i^*) \ V_l^{C^*} \qquad \text{(B11)}$$

Hence, *Proposition 5* is one of Nash equilibria, (a_i^* , C*), while solving simultaneous equations (B5) and (B8), when a_i and C are within the boundaries. Note that $a_i \in [0, 1)$ and C $\in$ [0, 1].

From Equation (B7), if $[0 < (U_h - U_l^C) < k \ \bar{a}]$, then $a_i^* = (U_h - U_l^C)/k$. Substitute a_i^* into (B11) , then $V_0 = a_i^* \ V_h + (1 - a_i^*) V_l^C$. From the first order condition ($\frac{\partial V_0}{\partial C} = 0$), we have C* = A as expressed in (B1) if 0 < A < 1. Hence, the "If" part of *Proposition 5* is proved. The "Only if " part of the proof ($\Leftarrow$) can be shown by reversing the procedure mentioned above.

Q.E.D.

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