



# Stock option contract adjustments: The case of special dividends<sup>☆</sup>

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## Abstract

The terms of stock option contracts are adjusted in the event of unexpected corporate actions, and the nature of the adjustments may result in windfall gains or losses to open option positions. This paper evaluates the fairness of the two different procedures used for special cash dividends. We show that, while neither procedure is technically correct, the absolute adjustment used in the U.S. and Canada minimizes the windfall change in option value when the dividend is announced. In addition, the proportional adjustment used in Australia and Europe depends on stock price and is therefore vulnerable to temporary aberrations in the stock market.

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## 0. Introduction

Stock option contracts are unusual to the extent that their terms must be adjusted to reflect unexpected corporate actions. Spinoffs, cash or stock takeovers, rights issues and special dividends are among the events that may trigger changes to the exercise price and expiration date of outstanding option positions. The fairness of the adjustment procedures

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is critical to market integrity. Neither the option buyer nor the option seller should suffer as a result of the action. Clearing authorities guard the integrity of outstanding contracts, and the fairness of contract adjustments for corporate actions is chief among their concerns. The stock option clearing authority in the U.S., the Options Clearing Corporation (OCC) in its bylaws states:

... all adjustments to the terms of outstanding cleared contracts shall be made by the Securities Committee, which shall determine whether to make adjustments to reflect particular events in respect of an underlying interest, and the nature and extent of any adjustment, based on its judgment as to what is appropriate for the protection of investors and the public interest, taking into account such factors as fairness to holder and writers (or purchasers and sellers) of affected contracts,...<sup>1</sup>

The purpose of this paper is to analyze the fairness of contract adjustment procedures used for one particular corporate event—a special cash dividend. As it turns out, different clearing authorities use different contract adjustment procedures. In the U.S. and Canada, the exercise price of the option is reduced by the amount of the dividend on the ex-dividend day. In Europe and Australia, on the other hand, the exercise price is reduced and the number of deliverable shares is increased proportionally by the ratio of the dividend relative to the cum-dividend stock price.

The fact that the second adjustment procedure depends on share price makes it susceptible also to temporary aberrations in the stock market. This was made abundantly clear recently when Altana AG, a specialty chemical company in Germany, paid a special dividend of €33 on shares trading at about €50. Published reports suggest that the last cum-dividend stock price was traded to an artificially low level, thereby affecting contract adjustment. When the stock price quickly returned to equilibrium levels, windfall gains (losses) were earned (incurred) by call option buyers (sellers). Market-making firms, which tend to be short options, bore the losses. One market-making firm reported a loss of \$37 million as a result of the increased cost of covering its short position in Altana call options.<sup>2</sup>

The outline of the rest of the paper is as follows. In the first section, we describe in detail the absolute and proportional contract adjustments and show that, if the underlying stock's volatility rate does not change as a result of the special dividend, the proportional contract adjustment produces no change in option value. The assumption that volatility does not change is implausible, however, since the disbursement of cash must cause firm's stock return volatility to rise. In the second section, we examine the characteristics of firms about to pay special dividends. We find that firms generally have large known cash balances and few investment opportunities. In the third section, we explain why standard option valuation models fail to account for the effects of dividend payments correctly and show how to model the effect of the cash disbursement on the stock's volatility rate using a displaced diffusion process. In the fourth section, we use the displaced diffusion option valuation model to determine the preferred adjustment procedure. The absolute adjustment is shown to be fairest to both long and short option holders. In section five, we examine the sensitivity of the proportional contract adjustment to stock price using

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<sup>1</sup>The Options Clearing Corporation By-Laws, Adjustment Panel Policies and Procedures, Section 11 of Article VI.

<sup>2</sup>See Forbes.com, "Interactive Brokers Cries Foul," July 6, 2007, and IBG Inc. Annual Report, 2007.

Altana's large special dividend in May 2007. Because the proportional adjustment depends on the last cum-dividend stock price and the stock price appears to have been taken to an artificially low level, long (short) call option holders experienced windfall gains (losses). The final section contains a summary of the study and its main conclusions.

### 1. Adjusting for special dividends: Absolute versus proportional procedure

The terms of stock option contracts are generally not adjusted for regular cash dividend payments. The reason is simple. Since the amount and the timing of regular dividend payments are known or predictable, their effects on option value are known by market participants well in advance of payment. Left unprotected, unexpected special (or extraordinary) dividends cause unexpected changes in option value. As a result, option exchange clearing authorities attempt to mitigate the unexpected changes in option value by making immediate adjustments to the terms of the stock option contract. For stock options traded on exchanges in the U.S. and Canada,<sup>3</sup> the exercise price of the option is reduced by the absolute amount of the special dividend on the ex-dividend day.<sup>4</sup> We refer to this adjustment as the absolute adjustment because it depends only on the dollar dividend. For stock options traded on exchanges in Europe and Australia,<sup>5</sup> two proportional adjustments are made, both based on what is dubbed the “*R*-factor.” The *R*-factor is defined as the proportion of share price that remains after the dividend is paid, that is,

$$R \equiv \frac{S-D}{S}, \quad (1)$$

where *S* is the cum-dividend stock price, and *D* is the amount of the special dividend. On the ex-dividend day, (a) the exercise price is reduced by a factor of *R* (i.e., from *X* to *RX*), and (b) the number of deliverable shares is increased by a factor of 1/*R* (e.g., if the original number of shares deliverable on the option is 100, it is increased to 100/*R*). Since this adjustment depends on the dividend relative to the stock price, we dub it the relative or proportional contract adjustment.

Presumably the objective of both the absolute and proportional adjustment procedures is to leave option holders, both long and short, as well off at the instant after the special dividend is announced as they were the instant before. Interestingly enough, except in one special case, neither procedure is completely accurate. The one special case is where the payment of the special dividend does not affect the underlying stock's volatility rate. For this case, Merton (1973, p. 149, Theorem 9) shows that the proportional adjustment procedure produces an ex-dividend option value equal to its cum-dividend level because

<sup>3</sup>In the U.S., the clearing authority for the six options exchanges is the Options Clearing Corporation (OCC). In Canada, all stock options trade on the Bourse de Montréal and the clearing authority is the Canadian Derivatives Clearing Corporation (CDCC).

<sup>4</sup>In the event that the dividend adjustment creates an exercise price that is not supported by the OCC's clearing system (i.e., exercise prices are quoted in eighths), the amount of the dividend is added to the stock price at expiration and no adjustment is made to the exercise price. If the special cash dividend is \$11.09 per contract, for example, the OCC will not adjust the exercise price and instead will add the cash to the deliverable at expiration. From a valuation standpoint, the adjustment procedures produce identical results.

<sup>5</sup>The largest stock options exchange in Europe is the Eurex, and its clearing authority is Eurex Clearing. In Australia, the largest stock options exchange is the Australian Securities Exchange, and its clearing authority is ACH.

option value is homogeneous of degree one in the stock price and exercise price, that is,

$$C(S, X) = \frac{1}{R} C(RS, RX), \quad (2)$$

where  $C(\bullet)$  represents the call option value as a function of the parameters included within the parentheses. The term on the left-hand side of (2),  $C(S, X)$ , is the cum-dividend value of the call option, and the term,  $C(RS, RX)$ , is the ex-dividend call option value where the number of deliverable shares is unchanged. The factor,  $1/R$ , increases the number of deliverable shares. Unfortunately, this case is implausible since the disbursement of cash from the firm cannot help but increase the stock's volatility rate. And, with increased volatility, the proportional contract adjustment procedure will induce a windfall increase in option value.

## 2. Firm characteristics when special dividends are paid

In choosing an option valuation framework that incorporates the effects of special dividend payments on the underlying stock, we need to understand the characteristics of firms that pay special dividends. To this end, we examine market prices, cash and short-term investment balances, and news releases in the months surrounding the announcement and payment of ten large special dividends during the January 2003 through December 2008 period. All of the payments were made under a regime where the OCC adjusted contract terms only when the special dividend was “large,” that is, greater than or equal to 10% of the closing stock price on the declaration date. Effective February 2009, adjustments are now made for all special dividends greater than or equal to 12.5 cents a share. As a result, the frequency of special dividend contract adjustments has increased dramatically.

The [Appendix](#) contains a summary of key firm characteristics for the ten large special dividends considered. In reviewing the details, the “typical” situation is obvious and intuitive.<sup>6</sup> A firm that pays a special dividend generally (a) has a large, known cash balance, whether accumulated through time or the sale of assets, (b) has no attractive investment opportunities, and (c) pays the special dividend to disburse all or part of the cash.

To illustrate, consider the first five special dividends (arranged in chronological order by announcement date) of the [Appendix](#).

*Iomega*: IOM announced a special dividend of \$5.00 a share (43.9% of the prevailing share price) on July 17, 2003. In the press release that accompanied IOM's dividend announcement, the firm's chairman was quoted as saying the board of directors had been “...exploring ways to improve shareholder return on the Company's excess cash...” but was unable to find anything that met its “...twin goals of attractive returns and safety for shareholders.”

*Microsoft*: MFST announced a special dividend of \$3 a share (10.1% of share price) on November 9, 2004. The fact that MSFT had an excessive cash balance and was contemplating a special dividend of more than \$10 billion was reported in the *Financial Times* more than a year earlier.

<sup>6</sup>A firm can, of course, issue debt or equity to pay for a special dividend. The costs of doing so, however, are high, so such events are rare, and, when they occur, usually involve tightly held firms.

*Commonwealth Telephone Enterprise:* CTCO announced a \$13 a share special dividend (25.7% of share price) on June 13, 2005. Nearly two years earlier, the *Wall Street Journal* reported that CTCO planned to look for acquisitions to use its accumulated cash balance over the next 12–18 months, and, if they could not find viable opportunities, would consider share repurchases or a special dividend.

*Saks:* SKS announced a \$4 a share special dividend (21.5% of share price) on March 6, 2006. More than 4 months earlier SKS announced the sale of its Northern Department Store Group for \$1.1 billion in cash and its intention to distribute a substantial portion of the sale proceeds to shareholders through repurchases, a special dividend, or a combination of both.

*Great Atlantic and Pacific Tea Company:* GAP announced a special dividend of \$7.25 a share (20.6% of share price) on April 4, 2006. Nine months earlier it had sold A&P Canada for \$1.2 billion in cash and \$500 in shares. The subsequent special dividend was intended to disburse part of the excess cash balance.

In summary, the story that emerges from examining firm characteristics before special dividend payments is that the firm is known to have two parts: (a) a viable business operation (risky assets) and (b) excessive balances in cash and/or short-term investments (risk-free assets). Since stock return volatility is simply a market-value weighted average of the return volatilities of these two asset categories, a special dividend announcement causes the market-value weight assigned to risky asset return volatility and, hence, the return volatility of the stock to rise.

### 3. Valuing stock options under displaced diffusion

Currently the finance literature does not have a completely satisfactory resolution on how to value stock options on dividend-paying stocks, independent of whether the cash dividends are regular or special. In the [Black-Scholes \(1973\)/Merton \(1973\)](#) model, for example, dividends are ignored and the stock price is assumed to follow a smooth, continuous process (i.e., geometric Brownian motion). Such a process does not permit discrete cash dividend payment schedules typically observed for common stock. [Roll \(1977\)](#) circumvents the problem by assuming that the stock price, net of the present value of the promised dividends, follows geometric Brownian motion. In doing so, he is able to derive an analytical formula for valuing an American-style call option on a dividend-paying stock.<sup>7</sup> The assumption, however, introduces a logical inconsistency—two options with different numbers of dividends paid during their lives will have different stock price processes. Indeed, in the extreme case of perpetual options, the volatility rate must fall to zero.<sup>8</sup>

#### 3.1. Valuing European-style options

Interestingly enough, a more satisfactory, but largely overlooked, stock price process exists for modeling the effects of discrete cash dividends—the displaced diffusion process. [Rubinstein \(1983\)](#) is the first to recognize the practical significance of displaced diffusion in stock option valuation and derives valuation formulas for European-style calls and puts.

<sup>7</sup>Whaley (1981) corrects a misspecification in the original [Roll \(1977\)](#) formula.

<sup>8</sup>This follows since the stock price is the present value of a known cash dividend stream.

His key assumption is that the firm has two assets: a risky asset with current value  $A$  (i.e., the market value of the assets driving the firm as an ongoing business concern) and a risk-free asset with current value  $CASH$  (i.e., the cash and short-term investment balances). Changes in the risky asset price are assumed to follow geometric Brownian motion with a constant volatility rate  $\sigma_A$ . If the firm is financed entirely with common stock, the stock price process is  $S \equiv A + CASH$ , hence the name “displaced diffusion.” Proportion  $\alpha (\equiv A/S)$  of the firm’s asset structure is the risky asset and  $1 - \alpha (\equiv CASH/S)$  is in risk-free interest-bearing cash. In the absence of dividends, the stock price at future time  $T$  is

$$\begin{aligned} \tilde{S}_T &= Ae^{\tilde{R}_A T} + CASH e^{rT} \\ &= S[\alpha e^{\tilde{R}_A T} + (1 - \alpha)e^{rT}], \end{aligned} \tag{3}$$

where  $\tilde{R}_A$  is the risky asset return and  $r$  is the risk-free interest rate. Under the assumption that the firm’s risky assets are tradable,<sup>9</sup> the current value of a European-style call option is

$$C = \alpha SN(d_1) - (Xe^{-rT} - S(1 - \alpha))N(d_2), \tag{4}$$

where  $X$  is the exercise price of the option,

$$d_1 = \frac{\ln(\alpha S / (Xe^{-rT} - S(1 - \alpha))) + 0.5\sigma_A^2 T}{\sigma_A \sqrt{T}}, \quad \text{and } d_2 = d_1 - \sigma_A \sqrt{T}.$$

### 3.2. Valuing American-style options

To value American-style options under the displaced diffusion assumption, an approximation method such as the [Cox-Ross-Rubinstein \(1979\)](#) (hereafter CRR) binomial method must be used. Since the risky asset, not the stock price, is the underlying source of uncertainty, the price lattice in the binomial procedure is for the risky asset. The up-step and down-step coefficients are  $u \equiv e^{\sigma_A \sqrt{\Delta t}}$  and  $d \equiv 1/u$ , respectively, and the up-step and down-step probabilities are  $p_u \equiv (1/2) + (1/2)(r - 0.5\sigma_A^2 / \sigma_A) \sqrt{\Delta t}$  and  $p_d \equiv 1 - p_u$ , respectively, where  $\sigma_A$  is the volatility rate of the risky asset and  $\Delta t$  is the user-defined time increment.<sup>10</sup> Based on the risky asset price lattice, a stock price lattice is then developed. At the option’s expiration, the stock price at each node equals the sum of the risky asset price at the node and the terminal value of the risk-free asset,  $CASH e^{rT}$ . The option value at each terminal stock price node ( $t = T$ ) is then computed using:

$$C_t^i = \max(0, S_t^i - X), \tag{5}$$

where  $S_t^i$  is the stock price at node  $i$  of time  $t$ . The remaining steps for valuing American-style options using the binomial method are the same as in the standard model.<sup>11</sup> The option values for the nodes in the preceding time steps are computed by taking the present value of the expected future value, that is,

$$C_t^i = e^{-r\Delta t} (p_u C_{t+1}^{i+1} + p_d C_{t+1}^i). \tag{6}$$

<sup>9</sup>The assumption that risky assets are tradable is reasonable since the firm’s observed share price is simply the sum of the price per share of the underlying business concern and the price per share of the idle cash balance.

<sup>10</sup>The option’s time remaining to expiration  $T$  is divided into  $n$  discrete time increments, with each increment defined as  $\Delta t \equiv T/n$ .

<sup>11</sup>For an explanation and a numerical example, see [Whaley \(2006, pp. 304–312\)](#).

If the exercise proceeds are higher at that node, the option holder is assumed to rationally exercise the option immediately since it is worth more “dead” than “alive.”

### 3.3. Incorporating regular cash dividends

To introduce regular cash dividends into the displaced diffusion binomial option valuation procedure, we assume that the amount and the timing of the dividend payments made during the option’s life are known and that the present value of the dividends is less than or equal to the amount of cash (i.e., the risk-free asset) in the firm,<sup>12</sup> that is,

$$PVD = \sum_{i=1}^{n_D} D_i e^{-rt_i} \leq CASH, \quad (7)$$

where  $D_i$  is the amount of the  $i$ th dividend to be paid at time  $t_i$ , and  $n_D$  is the number of dividends paid during the option’s life. At the end of the option’s life, the value of risk-free assets remaining within the firm is

$$CASH e^{rT} - \sum_{i=1}^{n_D} D_i e^{r(T-t_i)}. \quad (8)$$

This amount gets added to each risky asset price node at time  $T$  to determine the corresponding stock price (in place of  $CASH e^{rT}$  that was added to the risky asset price node when no dividends are paid). As the binomial procedure steps backward in time, the value of the original risk-free cash (the first term in (8)) and the future value of the dividends (the second term in (8)) are reduced by a factor of  $e^{-r \Delta t}$ . Note that, if the  $i$ th dividend is paid after the current time step, it is not included in the second term of (8). By the time the binomial procedure returns to the current date, expression (8) equals the original amount of cash. All other steps in the binomial procedure are the same as before.

Table 1 illustrates the effects of dividend payments on the values of European- and American-style call and put options. Two dividend assumptions are made. In the first, a single dividend of 2 is paid in 60 days, and, in the second, two dividends of 2 are paid in 15 and in 105 days. Rubinstein’s (1983) formulas are used to compute the European-style call and put option values. In the one-dividend scenario, the present value of the dividend, 1.984, is subtracted from the value of the risk-free asset, so the stock price becomes 48.016 and the proportion of the firm in risky assets becomes  $\alpha = 45/48.016 = 0.937$ . Note that the stock’s volatility rate rises from 36% in the no-dividend case to 37.5% in the one-dividend case. The payment of the cash dividends makes the stock riskier, as expected. In the two-dividend scenario, the present value of the dividends is 3.967, the stock price is 46.033, the proportion of the firm in risky assets is  $\alpha = 0.978$ , and the stock’s volatility rate is 39.1%.

<sup>12</sup>Within this framework, paying the dividend from cash implies that the stock price falls by the amount of the dividend on ex-dividend day. The validity of this assumption has been examined empirically. Early studies of the stock price behavior on ex-dividend days date generally find that the stock price decline is smaller than the amount of the dividend. Campbell and Beranek (1955), for example, find an average decline of 90% of the dividend, which they attribute to the preferential tax treatment of capital gains vis-à-vis dividend income. Durand and May (1960) report an average value of 96%, and Elton and Gruber (1970) report 78%. In more recent work, Graham, Michaely, and Roberts (2003) show that since the introduction of decimal pricing and reduced tax rate differentials, the ratio has moved closer to one. Barone-Adesi and Whaley (1986) show that the stock price decline implied by option prices on dividend-paying stocks is not different from one from a statistical standpoint.

Table 1

Simulated values of European- and American-style call and put options using the displaced diffusion option valuation model.

Stock price is 50, risk-free interest rate is 5%,  $\alpha$  is 0.9, and volatility rate of risky asset is 40%. The options are assumed to have 120 days remaining to expiration. Two dividend assumptions are: (a) one dividend of 2 in 60 days, and (b) two dividends of 2 in 15 and 105 days. European-style values are computed using analytical formulas and American-style values are computed using binomial method.

Exercise Price	Call Option Value				Put Option Value			
	One Dividend		Two Dividends		One Dividend		Two Dividends	
	European	American	European	American	European	American	European	American
40	9.541	10.588	8.038	10.119	0.873	0.886	1.353	1.369
42	8.050	8.877	6.695	8.270	1.348	1.372	1.977	1.996
44	6.705	7.327	5.507	6.665	1.971	2.004	2.757	2.777
46	5.516	5.952	4.476	5.329	2.750	2.793	3.693	3.716
48	4.484	4.768	3.597	4.242	3.685	3.744	4.781	4.813
50	3.603	3.783	2.859	3.358	4.772	4.854	6.011	6.051
52	2.865	2.971	2.250	2.634	6.001	6.112	7.370	7.419
54	2.255	2.316	1.754	2.047	7.358	7.505	8.841	8.904
56	1.758	1.793	1.356	1.577	8.829	9.015	10.410	10.486
58	1.359	1.380	1.040	1.204	10.397	10.626	12.062	12.148
60	1.042	1.055	0.792	0.911	12.048	12.320	13.781	13.876

In Table 1, both the American-style call and the put options have sizable early exercise premiums. The value of the European-style call with a 40 exercise price, for example, is 9.541 while the corresponding American-style call value is 10.588. The difference in value, 1.047, is the early exercise premium. In the presence of cash dividends, the call may optimally be exercised early just prior to the ex-dividend date. Note that the value of the 40 American-style call is 11.179 with no dividends, 10.588 with one dividend, and 10.119 with two dividends. The greater the amount of cash paid out by the firm, the lower the call option value. The effect of dividend payments on the value of the put is just the opposite.

#### 4. Determining fairest special dividend contract adjustment

We now turn to analyzing the valuation effects of the special dividend contract adjustments. In the event that a firm announces a special dividend on a stock whose options trade in a U.S. or Canadian option market, the respective clearing corporations reduce the exercise price of the option by the absolute amount of the special dividend on the ex-dividend day. In European and Australian option markets, the authorities reduce the contract exercise price and increase the number of deliverable shares proportionally by the ratio (1).

It is straightforward to value a stock option under the absolute contract adjustment procedure. Assuming the amount and the timing of the special dividend have been announced, Eq. (5) is used as the early exercise boundary condition for all call option nodes before the ex-dividend day, and the early exercise boundary condition,

$$C_t^i = \max(0, S_t^i - (X - D)), \quad (9)$$



is used for all option nodes on and after the ex-dividend day. Note that in (9) the exercise price is reduced by the amount of the dividend, as is prescribed by the option clearing corporations in the U.S. and Canada.

The modification to the binomial option valuation framework for the proportional contract adjustment procedure is more complicated. The reason is that the  $R$ -factor used to adjust the terms of the option contract on the ex-dividend day depends on the stock price. Consequently, in valuing the option, we cannot begin at the option's expiration and work backwards since we do not know what particular contract adjustment is made on the ex-dividend day. Instead, we develop the risky asset price and stock price lattice only through the ex-dividend day. At the ex-dividend instant, we know all of the nodal stock prices. At each node, we compute the  $R$ -factor using equation (1) and adjust the exercise price to a level of  $RX$ . Once we do so, we value the option at that node by applying the binomial procedure, where the option has an exercise price of  $RX$  and a time to expiration equal to the time between the ex-dividend day and the expiration date. This computed option value is then scaled by  $1/R$ , to complete the adjustment as prescribed by the clearing corporations in Europe and Australia. In other words, we nest binomial option valuation lattices within a binomial option valuation lattice to value the option nodes on the ex-dividend day.<sup>13</sup> We then proceed backward in time from the ex-dividend day using the standard binomial option valuation mechanics.

Table 2 contains simulation results. The column headed "Pre-announcement" contains option values *before* the market becomes aware that a special dividend is about to be declared. The next three columns make the assumption that a special dividend of 5 *has just been announced* and will be paid in one day. The column headed "No adjustment" contains the option values assuming the options are unprotected, as is the case for regular cash dividends. For the call with an exercise price of 40, the option value is 10, exactly equal to the exercise proceeds. This implies that the call should be exercised immediately before the stock goes ex-dividend. The calls with exercise prices of 42 and 44, likewise, should be exercised immediately since they are trading at their intrinsic values. The drop in value from the pre-announcement level reflects the fact that, with no contract adjustment for the surprise dividend, call options experience a windfall loss in value. Conversely, unprotected put options experience a windfall increase.

Recall that the purpose of the contract adjustments is to preserve the value of the option in light of the unexpected special dividend announcement. The absolute adjustment attempts to do this by reducing the exercise price by the amount of the dividend, and the proportional adjustment attempts to do this by multiplying the stock price and the exercise price by the  $R$ -factor and scaling the option position up by a factor of  $1/R$ . The "Absolute Adjustment" column in Table 2 contains the ex-dividend option values for the absolute adjustment, and the "Proportional Adjustment" column contains the ex-dividend option values for the proportional adjustment. Subtracting the cum-dividend option values from the ex-dividend levels of the absolute and proportional adjustment procedures produces the windfall changes in option value shown in the two right-most columns of the table. The 40-exercise price call option, for example, has a windfall value change of  $-0.071$  using the absolute contract adjustment procedure while the proportional adjustment has a windfall value change of  $0.249$ . In general, across the call and put option series considered in the

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<sup>13</sup>Fleming and Whaley (1994) use a similar technique to value the wildcard option embedded in the American-style S&P 100 index options.

Table 2

Simulated values of American-style call and put options using the displaced diffusion option valuation model.

Stock price is 50, risk-free interest rate is 5%,  $\alpha$  is 0.9, and volatility rate of risky asset is 40%. The options are assumed to have 120 days remaining to expiration. The firm is assumed to have just announced that a special dividend of 5 is to be paid in one day. Option values computed using binomial method.

## Panel A. Call Option values

Exercise Price	Pre-announcement	Post-announcement			Windfall Value Change	
		No Adjustment	Absolute Adjustment	Proportional Adjustment	Absolute Adjustment	Proportional Adjustment
40	11.176	10.000	11.105	11.425	-0.071	0.249
42	9.556	8.000	9.493	9.863	-0.063	0.307
44	8.067	6.000	8.008	8.426	-0.059	0.360
46	6.719	4.005	6.666	7.126	-0.053	0.407
48	5.524	3.201	5.476	5.966	-0.048	0.441
50	4.486	2.532	4.444	4.946	-0.042	0.460
52	3.601	1.983	3.571	4.063	-0.031	0.462
54	2.862	1.538	2.836	3.308	-0.026	0.447
56	2.253	1.181	2.228	2.672	-0.025	0.418
58	1.760	0.896	1.740	2.141	-0.020	0.381
60	1.363	0.681	1.348	1.702	-0.016	0.339

## Panel B. Put Option Values

Exercise Price	Pre-announcement	Post-announcement			Windfall Value Change	
		No Adjustment	Absolute Adjustment	Proportional Adjustment	Absolute Adjustment	Proportional Adjustment
40	0.530	1.685	0.540	0.781	0.010	0.251
42	0.884	2.407	0.900	1.192	0.016	0.309
44	1.369	3.288	1.389	1.731	0.020	0.362
46	2.001	4.328	2.024	2.410	0.024	0.409
48	2.790	5.521	2.817	3.232	0.027	0.442
50	3.743	6.856	3.774	4.201	0.032	0.458
52	4.856	8.320	4.894	5.311	0.038	0.454
54	6.121	9.897	6.160	6.555	0.039	0.434
56	7.524	11.572	7.561	7.924	0.036	0.400
58	9.052	13.331	9.088	9.407	0.035	0.355
60	10.687	15.167	10.721	10.990	0.033	0.303

table, the absolute contract adjustment procedure produces changes that are uniformly lower in absolute value than those of the proportional contract adjustment procedure, the absolute adjustment produces slightly lower (higher) values for call (put) options, and the proportional contract adjustment produces relatively large increases in value for both call and puts options.

The results of the simulations provided in Table 2 are sensitive to the parameter assumptions. While the absolute contract adjustment appears to work best in Table 2, this result may not hold across broad ranges of valuation parameters such as the volatility rate, the time remaining to expiration, and the proportion of the firm in risky assets. For this reason, we now turn to simulating value changes using realistic parameter ranges.

Table 3

Summary of special dividends greater than or equal to 12.5 cents per share from January 1996 to December 2008.

Number of special dividends appearing in the CRSP distribution file is 1,055. Of these, 322 are less than 12.5 cents. The remaining 733 special dividends are summarized below.

Decile No.	<i>n</i>	Average			No. of Days	Implied Share Price
		Dividend Amount	Share Price	Dividend Yield		
1	74	0.2534	52.46	0.0056	12.82	45.65
2	73	0.4535	41.16	0.0108	16.93	41.82
3	73	0.5723	32.20	0.0177	13.18	32.27
4	73	0.6426	27.81	0.0233	12.33	27.57
5	73	1.0433	30.52	0.0347	13.48	30.07
6	74	1.6264	32.05	0.0517	14.61	31.46
7	73	1.7744	20.64	0.0865	14.86	20.52
8	73	3.4152	23.58	0.1476	15.70	23.14
9	73	5.3003	21.26	0.2491	22.71	21.28
10	74	7.2983	14.49	0.5745	32.31	12.70
All	733	2.2413	29.63	0.1205	16.91	18.60

The most sensible place to begin is to develop an understanding of the typical size of special dividends paid in the U.S. Table 3 provides summary results. The numbers in the table are based on all special dividends appearing in the CRSP distribution file during the January 1996 through December 2008 period. In total, 1,055 special dividends appear in the file. Of these, 322 are less than 12.5 cents and are eliminated. The average special dividend amount across the 733 remaining special dividends (about 56 a year) is 2.2413, and the average share price is 29.63. Because we need the share price corresponding to a typical dividend, we compute the average dividend yield, and then infer the typical share price by multiplying the average dividend by the inverse of dividend yield. The average dividend yield is 0.1205, which means the implied stock price corresponding to the average dividend is 18.60. We now use these parameter estimates in a series of simulations.

Table 4 contains simulation results for a range of risky asset return volatility rate assumptions. The stock price is set equal to 18.60, and the proportion of the firm invested in risky assets is  $\alpha = (18.60 - 2.2413) / 18.60 = 0.8795$ . The stock is assumed to go ex-dividend (i.e., the special dividend of 2.2413) in 17 days. Panel A contains the option values just before the special dividend announcement is made. Panels B and C contain the percentage windfall changes in value resulting from the absolute and proportional contract adjustment procedures, respectively. The percentage changes are revealing. For the absolute adjustment, call option values fall and put option values rise, albeit by a small amount. The largest value change is  $-1.90\%$  for the 22.5 call at a volatility rate of 30%. For the proportional contract adjustment, the percentage windfall value changes are uniformly in the favor of the option buyer. The holder of the 22.5 call whose underlying risky asset return volatility is 30% increases in value by 36.49%.

Over the range of volatility rate assumptions considered, Table 4 shows: (a) the absolute contract adjustment procedure produces the lowest percentage changes in an absolute sense, (b) under the absolute contract adjustment, call option values fall slightly and put option values rise slightly, and (c) the proportional adjustment produces relatively large

Table 4

Simulated values of American-style call and put options using the displaced diffusion option valuation model.

Stock price is 18.60, risk-free interest rate is 5%, and  $\alpha$  is 0.8795. The options are assumed to have 120 days remaining to expiration. The firm is assumed to have just announced that a special dividend of 2.2413 is to be paid in 17 days. Option values computed using binomial method.

Panel A. Pre-announcement Option Values						
Volatility Rate	Call Option Exercise Prices			Put Option Exercise Prices		
	17.5	20	22.5	17.5	20	22.5
30%	1.906	0.701	0.197	0.533	1.837	3.921
40%	2.229	1.063	0.449	0.859	2.187	4.106
50%	2.565	1.439	0.754	1.196	2.557	4.382
60%	2.902	1.812	1.096	1.534	2.927	4.708
70%	3.239	2.181	1.444	1.874	3.295	5.047
80%	3.586	2.552	1.815	2.221	3.665	5.412
90%	3.931	2.928	2.182	2.567	4.040	5.775
100%	4.273	3.301	2.545	2.910	4.413	6.137

Panel B. Absolute Contract Adjustment						
Volatility Rate	Call Option Exercise Prices			Put Option Exercise Prices		
	17.5	20	22.5	17.5	20	22.5
30%	−1.12%	−1.46%	−1.90%	1.55%	0.67%	0.10%
40%	−0.83%	−1.11%	−1.03%	1.22%	0.58%	0.26%
50%	−0.70%	−0.78%	−0.76%	0.91%	0.55%	0.31%
60%	−0.60%	−0.60%	−0.64%	0.73%	0.51%	0.31%
70%	−0.46%	−0.48%	−0.58%	0.72%	0.47%	0.29%
80%	−0.40%	−0.48%	−0.45%	0.62%	0.39%	0.29%
90%	−0.36%	−0.40%	−0.36%	0.55%	0.36%	0.28%
100%	−0.32%	−0.34%	−0.29%	0.49%	0.34%	0.27%

Panel C. Proportional Contract Adjustment						
Volatility Rate	Call Option Exercise Prices			Put Option Exercise Prices		
	17.5	20	22.5	17.5	20	22.5
30%	6.24%	17.28%	36.49%	22.40%	6.18%	0.95%
40%	7.35%	16.33%	28.84%	19.06%	7.65%	2.62%
50%	8.22%	14.56%	24.16%	17.63%	8.04%	3.81%
60%	9.03%	14.30%	20.44%	17.05%	8.69%	4.53%
70%	9.63%	14.23%	19.27%	16.56%	9.27%	5.34%
80%	9.81%	13.98%	17.18%	15.76%	9.63%	5.64%
90%	9.95%	13.49%	16.86%	15.18%	9.70%	6.24%
100%	10.08%	13.13%	16.68%	14.74%	9.76%	6.79%

windfall increases in the values of both call and put options. Table 5 contains percentage windfall changes in value using different numbers of days to expiration, and Table 6 contains percentage windfall changes in value using different numbers of days to expiration and levels of  $\alpha$ . The results are qualitatively similar to those of Table 4.

In summary, the results reported in Tables 4–6 appear robust. While neither contract adjustment procedure is completely accurate from a fairness standpoint, the absolute

Table 5

Simulated values of American-style call and put options using the displaced diffusion option valuation model.

Stock price is 18.60, risk-free interest rate is 5%,  $\alpha$  is 0.8795, and the volatility rate is 50%. The firm is assumed to have just announced that a special dividend of 2.2413 is to be paid in 17 days. Option values computed using binomial method.

Panel A. Pre-announcement Option Values						
Days to Expiration	Call Option Exercise Prices			Put Option Exercise Prices		
	17.5	20	22.5	17.5	20	22.5
30	1.606	0.451	0.083	0.437	1.782	3.934
60	1.986	0.840	0.300	0.749	2.100	4.075
90	2.298	1.159	0.533	0.995	2.348	4.234
120	2.565	1.439	0.754	1.196	2.557	4.382
150	2.803	1.689	0.976	1.369	2.737	4.528
180	3.019	1.916	1.181	1.522	2.896	4.661
210	3.220	2.127	1.371	1.660	3.039	4.780
240	3.408	2.325	1.563	1.787	3.170	4.898

Panel B. Absolute Contract Adjustment						
Days to Expiration	Call Option Exercise Prices			Put Option Exercise Prices		
	17.5	20	22.5	17.5	20	22.5
30	−0.16%	−0.22%	−0.27%	0.24%	0.08%	0.01%
60	−0.39%	−0.47%	−0.63%	0.60%	0.28%	0.10%
90	−0.56%	−0.70%	−0.77%	0.77%	0.41%	0.20%
120	−0.70%	−0.78%	−0.76%	0.91%	0.55%	0.31%
150	−0.82%	−0.85%	−0.96%	1.02%	0.67%	0.38%
180	−0.93%	−0.91%	−0.95%	1.12%	0.78%	0.47%
210	−1.02%	−0.96%	−0.96%	1.23%	0.88%	0.55%
240	−0.98%	−1.00%	−1.21%	1.52%	0.98%	0.58%

Panel C. Proportional Contract Adjustment						
Days to Expiration	Call Option Exercise Prices			Put Option Exercise Prices		
	17.5	20	22.5	17.5	20	22.5
30	3.21%	11.16%	23.61%	11.71%	2.67%	0.34%
60	6.36%	14.66%	26.78%	16.77%	5.69%	1.70%
90	7.44%	15.02%	24.66%	17.16%	7.25%	2.81%
120	8.22%	14.56%	24.16%	17.63%	8.04%	3.81%
150	8.78%	14.65%	21.77%	17.96%	8.84%	4.37%
180	9.18%	14.61%	20.93%	18.19%	9.45%	4.95%
210	9.50%	14.58%	20.74%	18.38%	9.96%	5.54%
240	9.77%	14.54%	19.67%	18.54%	10.39%	5.89%

contract adjustment produces the smallest absolute changes in option value when a special dividend is announced. For the parameter ranges considered, the relative absolute change in value never exceeded 2%. The proportional contract adjustment, on the other hand, leads to windfall increases in the values of both calls and puts as a result of the stock return volatility increase implied by the announcement of the special dividend payment. The size

Table 6

Simulated values of American-style call and put options using the displaced diffusion option valuation model.

Stock price is 18.60, risk-free interest rate is 5%, and volatility rate is 50%. The options are assumed to have 120 days remaining to expiration. The firm is assumed to have just announced that a special dividend of 2.2413 is to be paid in 17 days. Option values computed using binomial method.

Panel A. Pre-announcement Option Values							
Alpha	Call Option Exercise Prices			Put Option Exercise Prices			
	17.5	20	22.5	17.5	20	22.5	
0.8795	2.565	1.439	0.754	1.196	2.557	4.382	
0.8295	2.464	1.336	0.675	1.095	2.455	4.308	
0.7795	2.364	1.232	0.595	0.994	2.353	4.235	
0.7295	2.263	1.128	0.516	0.894	2.252	4.165	
0.6795	2.163	1.024	0.437	0.793	2.151	4.098	
0.6295	2.066	0.920	0.369	0.695	2.051	4.042	
0.5795	1.972	0.822	0.301	0.601	1.956	3.989	
0.5295	1.879	0.724	0.238	0.507	1.862	3.947	

Panel B. Absolute Contract Adjustment							
Alpha	Call Option Exercise Prices			Put Option Exercise Prices			
	17.5	20	22.5	17.5	20	22.5	
0.8795	−0.70%	−0.78%	−0.76%	0.91%	0.55%	0.31%	
0.8295	−0.73%	−0.84%	−0.85%	0.99%	0.56%	0.30%	
0.7795	−0.76%	−0.91%	−0.96%	1.09%	0.57%	0.29%	
0.7295	−0.80%	−1.00%	−1.11%	1.22%	0.59%	0.26%	
0.6795	−0.83%	−1.10%	−0.99%	1.37%	0.60%	0.26%	
0.6295	−0.98%	−1.04%	−1.17%	1.30%	0.67%	0.23%	
0.5795	−1.02%	−1.12%	−1.43%	1.50%	0.69%	0.19%	
0.5295	−1.07%	−1.27%	−1.34%	1.79%	0.69%	0.15%	

Panel C. Proportional Contract Adjustment							
Alpha	Call Option Exercise Prices			Put Option Exercise Prices			
	17.5	20	22.5	17.5	20	22.5	
0.8795	8.22%	14.56%	24.16%	17.63%	8.04%	3.81%	
0.8295	7.94%	14.80%	24.33%	17.89%	7.88%	3.44%	
0.7795	7.70%	15.15%	24.56%	18.29%	7.74%	3.07%	
0.7295	7.54%	15.62%	25.78%	19.05%	7.60%	2.78%	
0.6795	7.45%	16.21%	28.57%	20.22%	7.43%	2.52%	
0.6295	7.18%	16.93%	28.87%	21.31%	7.22%	2.07%	
0.5795	6.67%	17.08%	30.21%	21.95%	6.76%	1.66%	
0.5295	6.14%	17.22%	33.76%	22.85%	6.24%	1.26%	

of the relative increases depends on the valuation parameters but can exceed 30%. The proportional adjustment is unambiguously detrimental to option sellers.

## 5. Analyzing Altana's contract adjustment

The valuation analyses conducted in the previous section show that, of the two special dividend contract adjustment procedures, the absolute adjustment is fairest to option

holders in the sense that option values are relatively unaffected by the special dividend announcement. As a postscript to our analysis, we describe another potential problem with using the proportional adjustment—its sensitivity to stock price. To do so, we use the controversy surrounding Altana AG's special dividend on May 4, 2007.

Altana AG is a developer and producer of innovative, high-quality products in the specialty chemicals industry. In 2006, Altana AG also owned a large pharmaceuticals subsidiary, Altana Pharma. In August 2006, the Danish drugmaker, Nycomed, expressed publicly an interest in buying Altana Pharma.<sup>14</sup> By the end of the year, the deal was consummated. Altana AG had accepted Nycomed's €4.5 billion cash offer. For the first few months of 2007, the funds were held as cash and marketable securities. On March 13, 2007, Altana AG's supervisory board approved a proposal to distribute the funds in the form of a special dividend of €33 per share. In addition, the board also approved a proposal for a regular dividend of €1.30 and a bonus dividend of €0.50. On May 3, 2007, the shareholders of Altana AG approved the supervisory board's proposals and the stock went ex-dividend on May 4, 2007. The total dividend payment amounted to €4,732 million, or 74.74% of the market value of the Altana's stock at the time.

We focus on the alleged manipulation of Altana's share price on May 3, 2007. Fig. 1 shows daily closing prices from March 16 to June 19, 2007—30 trading days before the last cum-dividend day through 30 days after May 3, 2007 the last cum-dividend day (denoted "day 0"). In Fig. 1, the stock prices before and including trading day 0 are closing "cum-dividend" closing prices as the dividend has not yet been paid (i.e., the impending €34.80 dividend payment remains impounded in the stock price). The stock prices after day 0 are also "cum-dividend" prices as €34.80 is added to the daily closing prices. The price plot is compelling. Before the ex-dividend day, the stock price rises slowly and smoothly, reaching a level of €54.49 two days before the last cum-dividend day (April 30 or day -2). Then, inexplicably, it drops to €51.82 on the next day (day -1) and to €46.56 at the close on the last cum-dividend day (day 0)—a drop of nearly 15% over two days. On ex-dividend day (day 1), the stock price rebounds to €54.60, and to €57.19 a day later—an increase of nearly 23%. It then reverses to close at what appears to be a more normal level, €54.40, on day 3 or May 8. Note that the stock price move from the day -2 to day 3 is €54.49 to €54.40 (or, in terms of actual prices, from €54.49 to €19.60 where a dividend of €34.80 has been paid)—almost exactly as it should be in an efficiently-functioning marketplace.<sup>15</sup> The pattern of prices for Altana in the days immediately surrounding the ex-dividend day appear abnormal. In particular, the closing price on the last cum-dividend day (day 0) appears dramatically below its equilibrium level.

To understand the effect of the stock price distortion on Altana's stock options, recall the definition of the  $R$ -factor (1). In the case of Altana AG on May 3, 2007, three dividends are about to be paid simultaneously: a regular dividend, a special dividend, and a bonus dividend. The special and bonus dividends affect the  $R$ -factor as follows:

$$R \equiv \frac{S_{cum-dividend} - D_{regular} - (D_{special} + D_{bonus})}{S_{cum-dividend} - D_{regular}}, \quad (10)$$

where  $S_{cum-dividend}$  is the stock price at the close on the day before ex-dividend. Although the dividend amounts in (10) are known, the  $R$ -factor is sensitive to the level of the cum-dividend

<sup>14</sup>See *Pharma Marketletter*, August 1, 2006.

<sup>15</sup>Recall that, in footnote 13, we discussed the empirical evidence regarding ex-dividend stock price drops in the U.S. In recent years, the price drop has not been significantly different from the amount of the cash dividend.

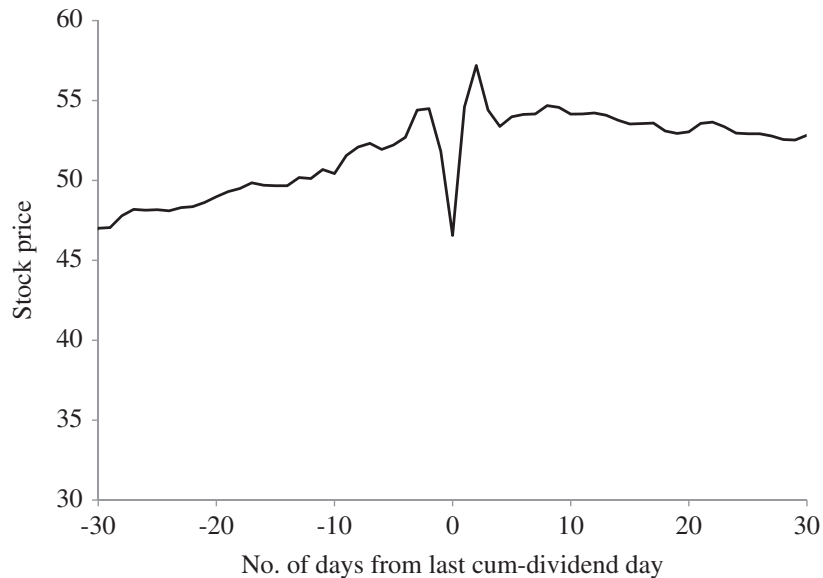


Fig. 1. Altana stock price in 30 calendar days before and after the last cum-dividend day, May 3, 2007. All stock prices are “cum-dividend.” Stock prices before and including day 0 are actual cum-dividend prices, while stock prices after day 0 are actual prices plus €34.80 (i.e., the sum of the regular dividend of €1.30, the bonus dividend of €0.50, and the special dividend of €33).

stock price  $S_{cum-dividend}$ . As noted above, the stock price fell by more than €5 on May 3, the last cum-dividend day.

Measuring precisely the economic consequences of the Altana stock price reversal in the option market is subjective in the sense that we need to specify Altana’s true stock price as of the close on May 3, 2007. In Fig. 1, several alternatives are discernible. One possibility is to use the previous day’s (day  $-1$ ) closing price, €51.82. But, this may be too low since the stock price fell dramatically on the previous day. A second possibility is to use the day  $-2$  stock price, €54.49, but this may be too high since the stock had recently run up in price. A third possibility is the stock price in the aftermath of the stock going ex-dividend. The average daily closing stock price over the 30-trading day from May 8 to June 19, 2007, for example, is €18.72. Adding the €34.80 in cash dividends to this average share price, the cum-dividend stock price is €53.52. For illustrative purposes, we use this estimate and assume that the “true” stock price is €53.52 as of the close on May 3 and that the “actual, but distorted” price is €46.56.

In measuring the economic consequences, we also need to specify the terms of the stock option contracts before the dividend, the risk-free interest rate, the ratio of the value of risky assets to the market value of the stock’s equity  $\alpha$ , and the risky asset return volatility rate  $\sigma_A$ . To represent typical contract terms, we use Altana’s nearby options, which expire on May 18, 2007. On the last cum-dividend day, these options have 15 days to expiration. The risk-free interest rate based on the 15-day ECU euro rate is 3.89%. To measure  $\alpha$ , we turn to Altana’s financial statements as of March 31, 2007. At the time, the sum of cash and marketable securities was €4,766 million, and the number of shares outstanding was 135,987,000. Our estimate of cash per share on May 3, 2007 is, therefore, €35. Dividing the cash by the estimated equilibrium share price, €53.52, and subtracting from one, the level of  $\alpha$  is 0.3460.



Finally, to estimate the volatility of the risky assets, we use the relation between the instantaneous volatility rates of the firm's risky assets and its stock,  $\sigma_A = \sigma_S/\alpha$ . To estimate the stock's volatility rate, we use the 83 daily returns from the beginning of January 2007 (when the divestiture of Altana Pharma was complete) through the end of April (before the abnormal price movements in the days surrounding the special dividend) and find that the annualized stock return volatility rate is 11.33%. At a level  $\alpha = .3460$ , the risky asset return volatility rate is 32.75%.<sup>16</sup>

Table 7 contains the simulated option values of the call and put options as of the close of trading on the ex-dividend day. Three separate cases are shown: (a) no distortion, (b) with distortion, and (c) with distortion and reversal. Under the columns headed "No distortion," the assumption is that the share price closed at its true level, 53.52, on the last cum-dividend day and remained at that level at the close on the ex-dividend day. With the stock price at 53.52, the  $R$ -factor for option adjustment is

$$R_{true} = \frac{53.52 - 1.30 - (33.00 + 0.50)}{53.52 - 1.30} = 0.3585.$$

All open option exercise prices are adjusted from their existing levels by a factor of 0.3585. The call and puts options with an original exercise price of €30, for example, have their exercise price adjusted to  $€30 \times 0.3585 = 10.75$ . At the same time, the number of shares of each option contract increases by a factor of  $1/R = 2.7895$ . With the original contract denomination of 100 shares, the ex-dividend contract denomination becomes 278.95 shares. Under the assumption that the stock price does not change from the close on the last cum-dividend to the close on the ex-dividend day, the close on the ex-dividend day is €18.72, that is, €53.52 less the regular dividend of €1.30, the bonus dividend of €0.50, and the special dividend of €33.00. Note that, where the cash per share was €35 before the dividend payments, it falls to €0.20 on the ex-dividend day. Where the level of  $\alpha$  is 0.3460 before the dividend payment, it rises to 0.9893 after the dividend payment. With the disbursement of cash, risky assets become a higher proportion of total assets. All of these figures are summarized in the panel immediately below the heading "No distortion."

Panels B and C in Table 7 contain call and put option values, respectively. To interpret the entries in these panels, consider the 30-call. The first column is the original exercise price. The "Adjusted Exercise Price" column is the exercise price after the contract adjustment. With an  $R$ -factor of 0.3460, the adjusted price is €10.75. The next column is the option value per share as of the close of trading on ex-dividend day (14 days to expiration). The stock price is €18.72, and the risk-free rate and the risky asset return volatility rate remain at 3.89% and 32.75%, respectively. The ex-dividend level of  $\alpha$  is 0.9893, as noted above, and there are no dividends paid during the option's remaining life. The value per share is €7.982, and, since the option now has a denomination of 278.95 shares, the contract value is €2,226.47.

In Table 7, under the columns headed "With distortion," the assumption is that the share price closed at an artificially low level of €46.56 on the last cum-dividend day and remained at this artificially low level at the close on the ex-dividend day. The panel immediately below the heading summarizes the changes in stock price-related parameters. The stock price falls from €46.56 on the cum-dividend day to €11.76 on the ex-dividend

<sup>16</sup>Interestingly, during the 83 trading days after the stock went ex-dividend window (May 8–September 4, 2007), Altana had an estimated realized stock return volatility rate of 28.41%, very close to the assumed level of 32.75%.

Table 7

Simulated values of Altana call and put options on ex-dividend day.

Binomial implementation of displaced diffusion option valuation model is used to value options. True cum-dividend stock price is €53.32 on last cum-dividend day. The actual, but distorted stock price is €46.56. The risk-free interest rate is 3.89%, the cum-dividend  $\alpha$  is 0.3460, and the risky asset return volatility rate is 32.75%. The options have 15 days remaining to expiration. A special dividend of €33.50 and a regular dividend of €1.30 have just been paid.

Panel A. Market Parameters

	No distortion: Stock price at true value on cum-dividend day and remains there on ex-dividend day.		With distortion: Stock price 6.96 below true value on cum-dividend day and remains there on ex-dividend day.		With distortion and reversal: Stock price 6.96 below true value on cum-dividend day and reverses to true value on ex-dividend day.	
	Cum-dividend	Ex-dividend	Cum-dividend	Ex-dividend	Ex-dividend	Ex-dividend
Stock Price	53.52	18.72	46.56	11.76	18.72	18.72
Cash	35.00	0.20	35.00	0.20	0.20	0.20
Risky Assets	18.52	18.52	11.56	11.56	18.52	18.52
Alpha	0.3460	0.9893	0.2483	0.9830	0.9893	0.9893
R-factor		0.3585		0.2598	0.2598	0.2598
1/R		2.7895		3.8486	3.8486	3.8486
No. of Shares	100	278.95	100	384.86	384.86	384.86

Panel B. Call Option Values

Original Exercise Price	Adjusted Exercise Price	Option Value Per Share	Contract Value	Original Exercise Price	Adjusted Exercise Price	Option value Per Share	Contract Value	Gains from distortion			
								Option Value Per Share	Contract Value	Revision Plus Stock Price Move	
30	10.75	7.982	2,226.47	30	7.79	3.977	1,530.47	10.937	4,209.12	1,982.65	2,678.65
35	12.55	6.192	1,727.21	35	9.09	2.679	1,031.21	9.639	3,709.86	1,982.65	2,678.65
40	14.34	4.402	1,227.96	40	10.39	1.388	534.19	8.342	3,210.61	1,982.65	2,676.42
45	16.13	2.615	729.56	45	11.69	0.340	130.92	7.045	2,711.35	1,981.79	2,580.43
50	17.92	0.987	275.46	50	12.99	0.020	7.77	5.748	2,212.10	1,936.63	2,204.33
55	19.72	0.147	41.11	55	14.29	0.000	0.08	4.451	1,712.84	1,671.74	1,712.77

60	21.51	0.007	1.86	60	15.59	0.000	0.00	3.154	1,213.77	1,211.91	1,213.77
65	23.30	0.000	0.02	65	16.89	0.000	0.00	1.879	723.31	723.29	723.31

Panel C. Put Option Values

Original Exercise Price	Adjusted Exercise Price	Option Value Per Share	Contract Value	Original Exercise Price	Adjusted Exercise Price	Option Value Per Share	Contract Value	Option Value Per Share	Contract Value	Gains from distortion	
										Contract Value	Revision
30	10.75	0.000	0.00	30	7.79	0.000	0.00	0.000	0.00	0.00	0.00
35	12.55	0.000	0.00	35	9.09	0.000	0.00	0.000	0.00	0.00	0.00
40	14.34	0.000	0.00	40	10.39	0.006	2.24	0.000	0.00	0.00	-2.24
45	16.13	0.003	0.87	45	11.69	0.256	98.58	0.000	0.00	-0.87	-98.58
50	17.92	0.165	46.16	50	12.99	1.241	477.71	0.000	0.00	-46.16	-477.71
55	19.72	1.120	312.55	55	14.29	2.531	974.00	0.000	0.00	-312.55	-974.00
60	21.51	2.789	778.00	60	15.59	3.830	1,474.00	0.000	0.19	-777.81	-1,473.81
65	23.30	4.581	1,278.00	65	16.89	5.129	1,974.00	0.023	9.00	-1,269.00	-1,965.00

day. With the stock price being at an artificially low level, the  $R$ -factor for option adjustment is lower

$$R_{actual} = \frac{46.56 - 1.30 - (33.00 + 0.50)}{46.56 - 1.30} = 0.2598.$$

All open option exercise prices are adjusted from their existing levels by a factor of 0.2598. The call and puts options with an original exercise price of the €30, for example, have their exercise price rewritten as  $€30 \times 0.2598 = 7.79$ . At the same time, the number of shares of each option contract increases by a factor of  $1/R = 3.8486$ . The two panels (A and B) below the top panel are ex-dividend day call and put option values. Consider the 30-call. The first column is the original exercise price. The “Adjusted Exercise Price” column is the exercise price after the contract adjustment. With an  $R$ -factor of 0.2598, the adjusted exercise price is €7.79. The ex-dividend stock price is 11.76, the risk-free rate is 3.89%, and the risky asset volatility rate is 32.75%. The ex-dividend level of  $\alpha$  is 0.9830, as noted above, and there are no dividends paid during the option’s remaining life. The value per share is €3.977, and, since the option now has a denomination of 384.86 shares, the contract value is €1,530.47.

Economic consequences are summarized in Table 7 under the panel headed “With distortion and reversal.” Under this scenario, the stock price is assumed to be driven from its true level of €53.52 just before the close of trading on the last cum-dividend day to an artificial level of €46.56, and then the stock returns to its true level of €53.52 by the close of trading on the following day. Since the stock price reverses to its true level, the original 30-call (now the 7.79-call) has a value per share of €10.937 at the close on ex-dividend day. With each option having a denomination of 384.86 shares, the value of one 7.79-call option contract is €4,209.12. The economic consequences are therefore as follows. First, since the  $R$ -factor was set at an artificially low level, the call option holder now has more shares than he should have. Since the cost of exercising the call remains the same after the contract adjustment (i.e.,  $30 \times 100$  shares is the same as  $7.79 \times 384.86$  shares), the long call option holder has a position value that has increased in value as a result of being awarded more shares. The value of the additional shares is  $(384.86 - 278.95) \times 18.72$  or €1,982.65. The column headed “Revision Plus Stock Price Move” includes not only the €1,982.65 contract revision effect but also an additional premium of €696.00 from acquiring the option position at a deflated price (i.e., €1,530.47 vs. €2,226.47).

In summary, if the stock price deviates from its true level on the last cum-dividend day and then returns to its true level afterward, windfall gains/losses arise from the proportional contract adjustment. The gains/losses arise from two sources: incorrect contract adjustment (e.g., €1982.65 in the case of the 30-call) and stock price movement (e.g., €696.00 in the case of the 30-call). If the distorted stock price is below the true price, long call option holders benefit and short call option holders lose, with the benefit/loss being greatest for in-the-money calls.<sup>17</sup> Note that the gains from distortion for the put options in Table 7 are negative. In other words, long (short) put option holders lose (gain) if the stock price is below its equilibrium level on the last cum-dividend day. Naturally, if the stock price is above its equilibrium level, the reverse is true. Whatever the direction,

<sup>17</sup>Anecdotally, the Altana call option with the highest trading volume and open interest on May 3, 2007 had an exercise price of 28.

however, the proportional contract adjustment provides a potential profit opportunity if it is possible to move the stock price from its equilibrium level.

## 6. Conclusion

We analyze the economic consequences of two commonly applied procedures for adjusting the terms of a stock option contract when the underlying stock pays an unexpected special dividend. The first is the absolute adjustment used in the U.S. and Canada. On the ex-dividend day, the exercise price is reduced by the amount of the special dividend. The second is the proportional adjustment used in Australia and Europe. On the ex-dividend day, the exercise price is reduced and the number of options is increased by a ratio that reflects the amount of the dividend relative to the cum-dividend stock price. In assessing the fairest procedure, we explicitly model the effect that cash dividends have on the underlying stock's volatility rate. We explain how standard option valuation models fail to account for the changes in volatility and show how Rubinstein's (1983) displaced diffusion model can. Based upon the displaced diffusion option valuation methodology, we assess the economic effects of the different adjustment procedures and show that the absolute adjustment is fairest from the option holder's standpoint. We also show that the proportional adjustment can be manipulated if the stock price can be moved from its equilibrium level.

## Appendix A. Sample of special dividends paid by U.S. firms from 2003 to 2009

Firm characteristics are drawn from the CRSP daily data file, financial statements, and public press articles (see Table A1).

Table A1

### (1) Iomega (IOM)

Special dividend amount per share:	\$5.00
Total dividend payment:	\$257 million
Source of funds:	Cash
Declaration date:	7/17/2003
Ex-dividend date:	10/2/2003
Share price on announcement date:	\$11.40
Dividend as a percent of stock price:	43.9%
Cash and ST investments balance in quarter before dividend announcement:	\$452 million
Cash and ST investments balance in quarter after dividend payment:	\$169 million
Announcement details:	
7/17/2003	

In announcing the special dividend, Iomega Chairman David J. Dunn said the Board of Directors had been "... exploring ways to improve shareholders return on the Company's excess cash." He said Iomega had considered using the cash for acquisitions but was unable to find anything that met its "... twin goals of attractive returns and safety for shareholders."

Table A1 (continued)

**(2) Microsoft (MSFT)**

Special dividend amount per share:	\$3.00
Total dividend payment:	\$32 billion
Source of funds:	Cash
Declaration date:	11/9/2004
Ex-dividend date:	11/15/2004
Share price on announcement date:	\$29.77
Dividend as a percent of stock price:	10.1%
Cash and ST investments balance in quarter before dividend announcement:	\$64.4 billion
Cash and ST investments balance in quarter after dividend payment:	\$34.5 billion

## Announcement details:

7/3/2003	The <i>Financial Times</i> reports that Microsoft is considering a special dividend of more than \$10 billion to reduce its cash balance. Other options include a share buyback, acquisitions and higher ordinary dividends, or a mixture of these.
7/18/2003	Microsoft CFO John Connors responds suggestions from analysts and investors that it use its cash to pay a dividend, saying that the cash is required to pay for potential antitrust litigation from the European Union and Sun Microsystems Inc.
3/24/2004	European antitrust decision is made and analysts expect that the resolution of Microsoft's legal issues should free the company to distribute some of its cash reserves to shareholders.
7/20/2004	Microsoft announces plan to pay a \$3 per share special dividend subject to shareholder approval.

**(3) Commonwealth Telephone Enterprises (CTCO)**

Special dividend amount per share:	\$13.00
Total dividend payment:	\$295 million
Source of funds:	Cash
Declaration date:	5/3/2005
Ex-dividend date:	6/13/2005
Share price on announcement date:	\$50.65
Dividend as a percent of stock price:	25.7%
Cash and ST investments balance in quarter before dividend announcement:	\$337 million
Cash and ST investments balance in quarter after dividend payment:	\$82 million

## Announcement details:

6/25/2003	The <i>Wall Street Journal</i> reports that CTCO is looking for acquisitions, but if they cannot find a viable opportunity in 12–18 months they will consider using their accumulated cash for share repurchases or a dividend payment.
5/3/2005	CTCO announces \$13 per share special dividend. In describing the dividend, President and CEO of CTCO Mike Mahoney said that it is "... the best use of a substantial portion of our cash at this time for our shareholders."

**(4) Saks Inc. (SKS)**

Special dividend amount per share:	\$4.00
Total dividend payment:	\$550 million
Source of funds:	Sale proceeds
Declaration date:	3/6/2006
Ex-dividend date:	5/2/2006
Share price on announcement date:	\$18.61

Table A1 (continued)

Dividend as a percent of stock price:	21.5%
Cash and ST investments balance in quarter before dividend announcement:	\$1,152 million
Cash and ST investments balance in quarter after dividend payment:	\$501 million
Announcement details:	
10/31/2005	SKS announces that it has agreed to sell its Northern Department Store Group (NDSG) for \$1.1 billion in cash plus the assumption of liabilities. Steve Sadove, the CEO of SKS, indicates that it intends to distribute a “substantial portion” of the sale proceeds to shareholders through share repurchases, a special dividend, or a combination of both. The deal is expected to be completed in the first quarter of 2006
3/1/2005	SKS announces that it intended to declare a special dividend of \$4 per share immediately following the closing of the sale of the NDSG, expected on March 13, 2005.
3/6/2005	The sale of NDSG is completed, and SSKS announces that its Board of Directors has authorized the special dividend.
<b>(5) Great Atlantic and Pacific Tea Co. (GAP)</b>	
Special dividend amount per share:	\$7.25
Total dividend payment:	\$300 million
Source of funds:	Sale proceeds
Declaration date:	4/4/2006
Ex-dividend date:	4/12/2006
Share price on announcement date:	\$35.13
Dividend as a percent of stock price:	20.6%
Cash and ST investments balance in quarter before dividend announcement:	\$543 million
Cash and ST investments balance in quarter after dividend payment:	\$262 million
Announcement details:	
7/19/2005	GAP announces that it has sold A&P Canada to Metro Inc. for \$1.2 billion in cash and \$500 million in shares.
4/4/2006	GAP announces a \$7.25 special dividend. Executive Chairman of the Board of Directors Christian Haub says that the move reflects “... the substantial resources we have on our balance sheet as a result of last year’s sale of A&P Canada.”
<b>(6) Saks Inc. (SKS)</b>	
Special dividend amount per share:	\$4.00
Total dividend payment:	\$550 million
Source of funds:	Cash and sale proceeds
Declaration date:	10/3/2006
Ex-dividend date:	12/1/2006
Share price on announcement date:	\$17.57
Dividend as a percent of stock price:	22.8%
Cash and ST investments balance in quarter before dividend announcement:	\$501 million
Cash and ST investments balance in quarter after dividend payment:	\$278 million
Announcement details:	
8/2/2006	SKS announces that it has agreed to sell its Parisian department store to Belk for \$285 million in cash. The company reiterates that it intends to distribute part of its existing cash balance and the net proceeds from the Parisian sale to shareholders.

Table A1 (continued)

10/2/2006	Sale of Parisian is completed.
10/3/2006	SKS declares special dividend of \$4 per share.
<b>(7) National Information Consortium (EGOV)</b>	
Special dividend amount per share:	\$0.75
Total dividend payment:	\$47 million
Source of funds:	Cash
Declaration date:	1/31/2007
Ex-dividend date:	2/8/2007
Share price on announcement date:	\$5.27
Dividend as a percent of stock price:	14.23%
Cash and ST investments balance in quarter before dividend announcement:	\$82 million
Cash and ST investments balance in quarter after dividend payment:	\$33 million
Announcement details:	
1/31/2007	In announcing the special dividend Jeff Fraser, Chief Executive Officer of National Information Consortium (NIC), said that "... the strength of our balance sheet and confidence in the future prospects of NIC prompted the Board of Directors to declare this special cash dividend."
<b>(8) Heartland Express (HTLD)</b>	
Special dividend amount per share:	\$2.00
Total dividend payment:	\$197 million
Source of funds:	Cash
Declaration date:	5/14/2007
Ex-dividend date:	5/22/2007
Share price on announcement date:	\$16.86
Dividend as a percent of stock price:	11.9%
Cash and ST investments balance in quarter before dividend announcement:	\$365 million
Cash and ST investments balance in quarter after dividend payment:	\$173 million
Announcement details:	
5/14/2007	Heartland Express Inc. declares a special dividend of \$2 per share. No additional details were announced.
<b>(9) Steelcase Inc (SCS)</b>	
Special dividend amount per share:	\$1.75
Total dividend payment:	\$248 million
Source of funds:	Cash
Declaration date:	12/19/2007
Ex-dividend date:	12/28/2007
Share price on announcement date:	\$15.15
Dividend as a percent of stock price:	11.6%
Cash and ST investments balance in quarter before dividend announcement:	\$544 million
Cash and ST investments balance in quarter after dividend payment:	\$264 million
Announcement details:	
12/19/2007	Steelcase announces the special dividend. In making the announcement, the CFO David C. Sylvester said the firm's "... targeted cash balance has been reduced, allowing for the declaration of the special dividend today."



Table A1 (continued)

**(10) Innovative Solutions and Support Inc (ISSC)**

Special dividend amount per share:	\$1.00
Total dividend payment:	\$17 million
Source of funds:	Cash proceeds of lawsuit
Declaration date:	9/8/2008
Ex-dividend date:	9/16/2008
Share price on announcement date:	\$6.15
Dividend as a percent of stock price:	16.26%
Cash and ST investments balance in quarter prior to dividend payment:	\$41 million
Cash and ST investments balance in quarter after dividend payment:	\$35 million
Announcement details:	
11/7/2007	ISSC receives favorable verdict in its trade secret misappropriation case against Kollsman, J2 Inc. and other defendants. The court awards damages of more than \$6 million and will hear claims for punitive damages.
7/7/2008	Court awards additional damages, bringing the total to \$23 million.
9/3/2008	ISSC reaches settlement with Kollsman Inc. for an agreed payout of \$17 million.
9/8/2008	ISSC announces a special dividend of \$1 per share said that the special dividend will be funded in cash from the \$17 million proceeds received in connection with a settlement with Kollsman, Inc.

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