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Levered and inverse VIX ETP option contract adjustments: No harm, no foul?

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Abstract

The terms of exchange-traded stock option contracts are usually adjusted when corporate actions take place. These adjustments are made to safeguard the value of the outstanding option contracts. Recently, a new type of corporate event has appeared – levered and inverse exchange-traded product issuers are reducing leverage ratios with increased frequency. While such changes directly affect option values, no contract adjustments are made, resulting in windfall transfers of wealth from outstanding long to outstanding short option holders. In one instance alone, the transfer was more than $US100 million. To remedy the problem, we offer a simple contract adjustment procedure.

Key words: Levered and inverse ETPs; Option contract adjustments; Wealth transfers

JEL classification: G10, G13, G23, G28

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1. Introduction

In the US, the Options Clearing Corporation (OCC) is responsible for adjusting the terms of outstanding exchange-traded stock option contracts when corporate actions such as stock dividends, stock splits, reverse stock splits, rights offerings, reorganisations, recapitalisations and reclassifications

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occur. These adjustments are made in a manner that is fair to outstanding long and short option holders.[1] Neither the long nor short option holder should be made worse off by a contract adjustment decision.[2] In many instances the contract adjustment is exact. In a two-for-one stock split, for example, the standard contract size of 100 shares becomes 200 shares and the option's exercise price of X becomes $X/2$. The market value of any existing option position is unchanged. In some instances, the contract adjustments and their consequences are not exact. Suppose a firm pays a large special cash dividend. In the US and Canada, the contract adjustment practice is to reduce the exercise price of the option by the absolute cash dividend amount because the stock price will fall by that amount on the ex-dividend day. In Europe and Australia, the reduction in exercise price is a proportion of the prevailing stock price. While both adjustments are intuitive, they are not exact. If the firm makes a large cash disbursement, the return volatility of the stock rises, causing an increase in option value. Existing long option holders gain at the expense of the short option holders.

The range of issues requiring option contract adjustments is large, and continues to grow larger with the proliferation of new types of underlying securities. The decision about whether to list a new stock option class rests with the exchanges. Here the term 'stock' refers to an equity security, which not only includes shares of common stock, but also index-linked securities such as exchange-traded funds. Exchanges have minimum listing standards to help ensure that newly launched option classes will have sufficient depth and liquidity. Nasdaq ISE/GEMX/MRX/PHLX rules, for example, require that the security is an 'NMS' security, with a minimum of (a) 7 million shares in float, (b) 2000 shareholders, and (c) 2.4 million shares in trading volume during the past 12 months. That is not to say that all stocks satisfying these criteria will have options listed. Nor is it to say that corporations cannot lobby exchanges to list their stocks or that market makers cannot lobby exchanges to list the options on a security with attractive volatility and volume attributes. Once one option exchange decides to launch a new option class, the other option exchanges usually follow.

This paper focuses specifically on contract adjustments for options on levered and inverse exchange-traded products. The main types of issuer actions are twofold. First, because of structural problems with their design, levered and

[1]See OCC Bylaws, Adjustments Policies and Procedures, Section 11. Specifically, 'all adjustments to the terms of outstanding cleared contracts shall be made by the Corporation [OCC], 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 holders and writers (or purchasers and sellers) of the affected contracts'.

[2]Like all derivatives contracts, option markets are a 'zero-sum game.'

inverse ETPs have frequent reverse splits.[3] Problems aside, the OCC adjusts the terms of existing option contracts with each reverse split in the usual fair manner. No harm, no foul. Second, levered and inverse ETP issuers change leverage factors of their funds. Recently, the changes have all been reductions. Such changes are presumably not in the interest of shareholders, whose decision to go long or short the ETP was based on its expected return/risk characteristics. Reducing the leverage ratio changes the fundamental nature of the security, thereby forcing the investor to re-optimise her investment portfolio allocations. Reducing the leverage ratio also reduces the probability of liquidation, however, thereby preserving at least some portion of the issuer's management fee revenue. Although these reductions change the fundamental nature of the underlying security, the OCC has had a policy of making no adjustment to terms of outstanding option contracts. No harm, no foul?

2. The big picture

In the US, adjustments to existing option contracts are not made for regular changes in the underlying security. Stock option contracts, for example, are not adjusted when regular quarterly cash dividends are paid. In the case of unusual or irregular events, however, adjustments are made. If a firm declares a large special cash dividend, outstanding option contracts typically have the exercise price reduced by the amount of the cash dividend. Such contract adjustments are made by the OCC and are memorialised by an 'Infomemo' describing the reason for the change (usually a corporate action of some sort), how the terms of existing option contracts will be adjusted, and when they become effective.

To place the various types of contract adjustments in perspective, we collected all Infomemos during the one-year period beginning 22 February 2017 and ending 23 February 2018, and tabulated their content by type of adjustment. A summary is provided in Table 1. In all, 708 Infomemos involving stock option contract adjustments were identified. The table uses seven different types of contract adjustment categories in terms of the action taken. The first category is labelled 'None' and it means there was no economic impact resulting from the OCC actions taken. A company may have had a change in name, ticker symbol or CUSIP number, or multiple option series including Flex options on the same underlying were consolidated under the same ticker symbol. The 187 changes have no economic impact. The 'Cash' category is where uncertainty about the underlying security's prospects is completely resolved (i.e., its volatility rate goes to zero), and the option is terminated early by virtue of a cash exchange. Included is this category are

[3]Inverse funds on securities indexes and both levered and inverse funds for commodity and volatility futures indexes have share prices that necessarily approach zero through time. Reverse splits are used to recalibrate share prices to higher levels for reporting and trading purposes. See Pessina and Whaley (2020).

Table 1
Analysis of OCC Infomemo information regarding frequency of contract adjustments to stock and ETP options by adjustment type during the one-year period 22 February 2017–23 February 2018

Adjustment	Frequency	Percent
None	187	26.4
Cash	137	19.4
Scale factor	140	19.8
Exercise price reduction	108	15.3
Shares	17	2.4
Shares and cash	106	15.0
Shares and other	13	1.8
	708	100.0

stocks acquired by a cash offer. In these instances, call (put) option holders with an exercise price above (below) the cash per share offer amount receive a cash payment of the difference. Also included would be stocks experiencing bankruptcy and having adjudicated prices of zero. In this instance, short call/long put option holders receive a cash payment of the exercise price.

The next row is labelled 'Scale factor' and refers to adjustments made as a result of stock splits, stock dividends and reverse stock splits. The adjustments here, too, are exact and involve little to no judgement. Merton (1973, p. 149, Theorem 9) shows that option value is homogeneous of degree one in stock price and exercise price, that is,

$$100 \times C(S, X) = 100 \times kC(S/k, X/k). \tag{1}$$

In Equation (1), $C(.)$ is an option valuation operator, which is a function of the stock price S and the exercise price X. The k-factor is any positive constant. In a two-for-one split, for example, $k = 2$. An outstanding long (short) option holder's position is revised such that he has twice as many deliverable shares at half the option value. In the case of a 10 percent stock dividend, $k = 1.1$, and, in a one-for-four reverse split, $k = 1/4$. The only imprecision in the adjustment procedure is potential rounding errors. In a 3-for-1 split, for example, an at-the-money option with an exercise price of 10 should have it reduced to $3.333333\overline{3}$. The price would be rounded to the nearest 'adjustment increment,' which in the case of options is one cent. The exercise price would be set at 3.33. A similar problem might arise with numbers of contracts. A 1-for-3 reverse split will produce fractional option contracts. Units of trading must be whole numbers.

All of the remaining categories in the table have inexact contract adjustments. They are defensible attempts at promoting fairness, however. The 'Exercise price reduction' row falls into this category. In our sample, there

were 108 occurrences in which there are special cash dividends or cash distributions. To get a sense for the problem here in this instance, consider an example. On 20 July 2004, Microsoft announced a special cash dividend of $US3.00 per MSFT common share, payable on 2 December 2004 to shareholders of record on 17 November 2004. The dividend amounted to 10.6 percent of the firm's share price at the time. Without an appropriate contract adjustment to existing option contracts, a special cash dividend of $US3.00, if paid during the option's life, would harm existing long call (short put) option holders in that the stock price should drop by the amount of the dividend on the ex-date, and would benefit the short call (long put) option holders by equal amounts. In the US, the OCC's contract adjustment procedure is to reduce the exercise price of existing option series by the amount of the cash dividend on the ex-dividend day.[4] On 20 July 2004, the same day as Microsoft announced its special dividend, the OCC announced that the exercise prices of existing option contracts would be reduced by $US3.00 on the ex-dividend date, 15 November 2004, presumably because the stock price will drop by that amount of the dividend, holding other factors constant. Certain subtleties in this procedure, as well as competing procedures, are discussed in Barraclough *et al*. (2012).

Like the exercise price adjustment category, the rows beginning with 'Shares' also have contract adjustments that are not exact. These are largely restructurings involving mergers, acquisitions, spinoffs and the like. What becomes the deliverable on the outstanding option contract is transformed into a different deliverable, which might be shares of a different company, cash, bonds, rights issues, warrant issues or some combination thereof. Such decisions are made by the OCC on a case-by-case basis. Since there is no limit on the corporate restructurings that might take place, there is no limit on the terms of the contract adjustments that might be made. Presumably an attempt is made to ensure that the value of the new deliverables equals the pre-existing deliverable. Invariably, the weightings will not be exact due to rounding errors and the like. And the new package is unlikely to have the same volatility rate. Modelling changes in volatility in such cases is a formidable task. Such is not the case for levered and inverse ETPs.

3. Relation between leverage ratio and volatility

Cheng and Madhavan (2009), hereafter 'CM', were the first to address the theoretical relation between the leverage ratio and return volatility for levered and inverse ETPs. Using Black-Scholes (1973)/Merton (1973), hereafter 'BSM', security price dynamics, they show that, if the underlying benchmark index has an expected price appreciation rate of μ and volatility of σ, a levered or inverse

[4]The same procedure is used in Canada, where the option clearing authority is the Canadian Derivatives Clearing Corporation (CDCC).

fund will have an expected price appreciation rate of $L\mu$ and volatility of $|L|\sigma$, where L represents the leverage ratio.[5]

To confirm that the leverage ratio has an effect on return, we turn to two specific leverage ratio changes made by ProShares in February 2018. By way of background, ProShares launched its ($2x$) Ultra VIX Short-Term Futures (UVXY) and its ($-1x$) Short VIX Short-Term Futures (SVXY) ETFs on 3 October 2011. The benchmark for both funds is the S&P 500 VIX Short-term Futures Index (SPVXSP). By 19 March 2012, less than a year later, UVXY and SVXY option trading commenced. After the market close on 26 February 2018,[6] ProShares unexpectedly announced that they would make large and immediate reductions in the leverage ratios of UVXY and SVXY. Effective as of close of business on 27 February 2018, the leverage ratios of UVXY would change from $2x$ to $1.5x$ and SVXY would change from $-1x$ to $-0.5x$.[7] Since the absolute magnitude of both leverage ratios is reduced, we will henceforth refer to both changes as 'leverage ratio reductions'. Naturally, the announcement was controversial. Such changes had been made previously. In 2011, Direxion announced that it would increase the leverage ratio of ten of its funds from $2x$ to $3x$. They did so with a lead time of 111 days, however. In the case of ProShares, the announcement was a complete surprise. When ProShares was asked 'Why weren't investors given more notice of the change?', ProShares answered that 'ProShares Capital Management believed that it was in the best interests of the funds and their shareholders to promptly implement this change'. On face appearance, it is not clear how the fund's and shareholder's interests are aligned. Shareholders, presumably, took positions based on the return/risk properties of the fund. Changing the leverage ratio changes the return/risk properties. Fund revenue, on the other hand, is based on assets under management. Preserving the longevity of the fund would seem to be in the manager's best interests.

Nonetheless, to verify the leverage ratio/volatility relation empirically, we collected daily price histories for SPVXSP, VIXY, UVXY and SVXY from Bloomberg. VIXY is ProShares ($1x$) VIX Short-term Futures ETF. The sample period, 5 October 2011 to 26 February 2020, is divided into two subperiods. The first subperiod begins 5 October 2011, the day UVXY and SVXY were launched, and ends 2 February 2018, the Friday before the collapse of Credit Suisse's popular inverse ($-1x$) ETN, XIV. We call this the 'pre-intervention period'. When VIX spiked on Monday, 5 February 2018, XIV lost 96.3 percent

[5]See Cheng and Madhavan (2009, p. 53).

[6]The earliest news wire that we were able to uncover was 'Press Release: ProShare Capital Management LLC Plans to Reduce Target Exposure On Two ETFs,' published by Dow Jones Newswires at 20.04 on 26 February 2018.

[7]Source: https://www.proshares.com/faqs/uvxy_svxy_investment_objective_changes.html

of its value, thereby triggering an acceleration event. In the following days, as XIV was being unwound, the creation/redemption process of all VIX ETPs was affected. Presumably, the increased basis risk motivated ProShares to reduce the leverage ratios of UVXY and SVXY on 27 February 2018. The second subperiod begins 28 February 2018, the day after the new leverage ratios took effect. We call the subperiod from 28 February 2018 to 26 February 2020 the 'post-intervention period'.

Table 2 contains summary statistics for the daily returns of each series in each of the two subperiods. They are reported in Panels A and B, respectively. The cumulative annual growth rates (CAGRs) of the benchmark index SPVXSP and its two long ETFs, VIXY ($1x$) and UVXY ($2x$), are negative. This is because the VIX futures price curve is typically upward sloping. Because VIX futures contract prices are usually higher than the corresponding expected future cash VIX levels, a condition called 'contango' (Keynes, 1930), VIX futures prices can be expected to decline as they approach expiration. Because products like VIXY and UVXY are long VIX futures, they can be expected to lose money over longer holding periods. Whaley (2013) dubs this the 'contango trap'. He documents that the CAGR of the SPVXSP was −36.0 percent over the period 20 December 2005, when the S&P 500 VIX Short-term Futures Index (SPVXSP) first appears, to 31 March 2012, the last date of his sample period. Our analysis uses more recent data and indicates that the contango trap has become worse. Over the period 5 October 2011 to 2 February 2018, the CAGR of the SPVXSP benchmark was −61.0 percent, as shown in Panel A of Table 2. Note also that the CAGR of UVXY ($2x$) ETF in Panel A is not two times the benchmark index. This is one of the confusing aspects of any levered or inverse fund. The fund promises L times the daily return of the benchmark index. The compounded levered return over periods longer than a day is (unpredictably) different from the levered compounded return, with the difference exacerbated by high return volatility. Pessina and Whaley (2020) provide a more detailed analysis of this phenomenon for the broad family of geared levered and inverse funds traded in the US.

With respect to the leverage ratio/volatility relation, the most important results are in the 'Volatility' rows in Panels A and B of Table 2. Not surprisingly, the realised return volatilities of the different ETFs conform to the promised leverage ratios. In the pre-intervention period (Panel A), the volatilities of VIXY and SVXY, both $|L| = 1$ products, are close to the volatility of SPVXSP. And the SPVXSP volatility in this more recent period is about the same as it was in the earlier sample period used by Whaley (2013). The benchmark volatility is high, making VIX ETPs instruments of choice for volatility speculation. UVXY, with its $2x$ leverage ratio, has a realised return volatility of a whopping 121.95 percent, just short of double that of the benchmark.

The post-intervention period produces the expected results. First, the return volatility of VIXY remains at about the same level as the benchmark and the

Table 2
Summary statistics from daily returns of S&P 500 VIX Short-term Futures Index (SPVXSP), ProShares VIX Short-term Futures ETF (VIXY), Ultra VIX Short-term Futures ETF (UVXY), and Short VIX Short-term Futures ETF (SVXY) for the sample period 5 October 2011–26 February 2020

	SPVXSP	VIXY	UVXY	SVXY
Panel A: Pre-intervention period from 5 October 2011 to 2 February 2018				
L		1	2	−1
CAGR	−60.99%	−61.34%	−90.47%	60.44%
Volatility	66.80%	61.48%	121.95%	63.55%
Panel B: Post-intervention period from 28 February 2018 to 26 February 2020				
L		1	1.5	−0.5
CAGR	−32.91%	−33.37%	−53.43%	6.64%
Volatility	61.49%	62.79%	92.55%	32.83%

L is the ETP's leverage ratio, CAGR is the cumulative annual growth rate, and volatility is the annualised daily standard deviation. CAGR and volatility are based on daily log returns. The sample sizes are 1,586 in the pre-intervention period, and 502 in the post-intervention period.

same level as it was in the pre-intervention period. This makes sense. VIXY did not experience a change in leverage ratio, and the level of volatility tends to persist through time. Just before the post-intervention period begins, ProShares changed the leverage ratio of UVXY from 2 to 1.5. Panel B shows that the return volatility of UVXY is 92.55 percent, about 1.5 times higher than the benchmark. No surprise. ProShares changed the leverage ratio of SVXY from –1 to –0.5. The return volatility of SVXY falls to 32.83 percent, about half the level of the benchmark. From both a theoretical and an empirical perspective, a change in the leverage ratio causes a direct and proportional change to return volatility, and return volatility is a fundamental determinant of option value.

4. Measuring economic impact

Equally surprising as ProShares' sudden announcement of the UVXY and SVXY leverage ratio reductions was the OCC's announcement on 27 February 2018, one day later, that the terms of the existing options on UVXY and SVXY would have no contract adjustments.[8] When ProShares was asked 'How do the changes affect exchange options on these funds?', ProShares answered that 'The Options Clearing Corporation issues and clears US-listed options. Neither

[8]OCC Information Memo #42683.

ProShares Capital Management nor the funds issue or sponsor options. The changes made to the funds' investment objectives considered the best interests of the funds and their shareholders'.

4.1. Setting the stage

To assess economic impact, we first set the stage. The announcement of the change in leverage ratios of UVXY and SVXY occurred unexpectedly at 20.04 on 26 February 2018. Markets were closed. With no active trading, the number of contracts outstanding for each option series is held constant, so we have an ideal laboratory for measuring the economic impact of the leverage ratio reduction. The economic value of existing option positions can be measured straightforwardly. For each option series, we take the product of its end-of-day bid/ask quote midpoint on 26 February, the number of contracts outstanding (i.e., the open interest),[9] and 100 (i.e., the standard contract size). We then sum across all of the option series for each ETF. The option data used in our analysis are from Cboe DataShop (https://datashop.cboe.com/). The file that we used is the *End-of-Day Options Quote Data* file, which provides the National Best Bid and Offer (NBBO) quote and size at the close of the day, together with the contemporaneous bid and ask quotes of the underlying ETFs. We use bid/ask midpoints at 14.45 Central Standard Time (CST).[10] We also include VIXY ($1x$) in our analysis. It is in the same family of ProShares ETFs benchmarked to the SPVXSP, and experienced no change to its leverage ratio.

Table 3 contains the results. The first row reports the number of option series on each of the ETFs. At the close on 26 February 2018, VIXY had 962 option series, 481 calls and 481 matching puts. The market value of the open interest in VIXY options was about $US5.6 million. At the same time, the total value of assets under management (AUM) was $US93.9 million. The ratio of dollar value of options to dollar value of underlying security, 6.0 percent, is higher than options on well-known stocks. On the same day, for example, Tesla's ratio was 2.7 percent, Amazon's was 1.0 percent and Apple's was 0.4 percent. It is more in line with options on ETPs. Statestreet's $1x$ SPY, for example, had a ratio of 3.8 percent, and ProShare's $2x$ and $-2x$ ETFs on a natural gas futures benchmark index, BOIL and KOLD, had ratios of 4.8 and 4.4 percent, respectively.

By comparison, the results for UVXY and SVXY are remarkable. The market value of open interest for UVXY options was $US463 million at the close on 26 February, while the AUM were $US342 million. The ratio in this case is a surprising 135.4 percent! Seldom is it the case that the market value of

[9]The open interest are the levels at the beginning of the day.

[10]The Cboe data set includes both quotes at 14.45 and 15.00 CST. The 14.45 quotes are provided because typically market makers widen bid/ask spreads approaching the close, presumably to discourage trading and avoid overnight inventory holding costs.

Table 3
Analysis of economic impact of change in leverage ratios of UVXY and SVXY announced after the close on 26 February 2018

Variable	VIXY	UVXY	SVXY
No. of option series	962	1,448	2,158
Assets under management (AUM)	93,891,466	342,118,382	796,571,760
Market value of open interest (MV of OI)	5,605,455	463,182,256	265,541,404
MV of OI as percentage of AUM	5.97%	135.39%	33.34%

the derivatives on a security exceeds the market value of the security itself. One possible explanation for the abnormally high demand is that traders replaced their direct holdings in XIV, which had recently collapsed, with put options on UVXY. On 26 February 2018, the market value of put options was about $US296 million versus $US165 million for calls (see Table 4). Finally, the market value of SVXY options to SVXY assets under management is 33.3 percent.

4.2. *Considering the paradox*

The most sensible way of thinking about the leverage ratio reduction is as the transformation of one security into another. Consider ProShares' family of SPVXSP products, VIXY ($1x$), UVXY ($2x$) and SVXY ($-1x$) preceding 26 February 2018. Each is offered by ProShares as a separate security; each is recognised by the OCC as having a separate option class. Yet, all of the securities are benchmarked to a single VIX futures benchmark index, SPVXSP. The differences are purely the leverage ratios. Before the change in leverage ratios on 26 February 2018, ProShares could hypothetically have had $1.5x$ and $-0.5x$ VIX ETF product offerings. Call these 'AVXY' and 'BVXY', respectively. They would have been recognised as separate funds and have had separate option classes. Now, consider the paradox. Making no contract adjustment to the terms of the outstanding options on UVXY and SVXY when their leverage ratios were reduced from $2x$ to $1.5x$ and $-1x$ to $-0.5x$, respectively, is equivalent to saying there are not security/option valuation differences for UVXY versus AVXY, and SVXY versus BVXY. That is false.

Another way to show the logical inconsistency is to consider the leverage ratio reductions as a liquidation. On 15 March 2020, ProShares announced the liquidation of OILU and OILD, its popular $3x$ and $-3x$ crude oil ETFs.[11] This decision meant 100 percent reductions in the respective hedge ratios. From a

[11]See https://www.proshares.com/news/proshares_announces_changes_to_etf_lineup_031220.html.

Table 4
Analysis of UVXY option losses as a result of reduction in leverage ratio from 2 to 1.5

		All		Call		Put	
No. of series		1,448		724		724	
Aggregate value		463,182,256		167,102,122		296,080,134	
Aggregate loss		84,450,610		46,398,980		38,051,631	
Percent loss		18.2%		27.8%		12.9%	
		Days to expiration					
	Days ≥	0	30	91	182	365	
	Days <	30	91	182	365	730	All days
Panel A: Call options							
In-the-money	No. of series	52	18	10	20	10	110
	Value	6,706,335	2,668,618	10,981,573	33,244,325	11,743,363	65,344,213
	Loss	126,202	151,623	513,934	2,726,256	967,649	4,485,665
	Percent loss	0.15%	0.18%	0.61%	3.23%	1.15%	5.31%
At-the-money	No. of series	48	34	6	12	6	106
	Value	7,603,149	1,988,266	3,773,615	11,414,465	825,443	25,604,938
	Loss	1,671,774	435,097	935,430	2,584,285	187,167	5,813,754
	Percent loss	1.98%	0.52%	1.11%	3.06%	0.22%	6.88%
Out-of-the-money	No. of series	237	95	44	90	42	508
	Value	6,441,015	2,117,588	7,828,109	46,953,601	12,812,660	76,152,972
	Loss	4,320,186	1,059,331	3,781,482	22,151,488	4,787,074	36,099,561
	Percent loss	5.12%	1.25%	4.48%	26.23%	5.67%	42.75%
All moneyness	Percent loss	7.24%	1.95%	6.19%	32.52%	7.04%	54.94%

(continued)

Table 4 (continued)

		Days to expiration					
	Days ≥	0	30	91	182	365	
	Days <	30	91	182	365	730	All days
Panel B: Put options							
Out-of-the-money	No. of series	52	18	10	20	10	110
	Value	691,814	876,341	4,623,441	20,222,911	5,920,178	32,334,683
	Loss	470,800	433,455	1,994,599	6,959,832	1,650,966	11,509,652
	Percent loss	0.56%	0.51%	2.36%	8.24%	1.95%	13.63%
At-the-money	No. of series	48	34	6	12	6	106
	Value	11,546,598	7,097,429	7,198,040	29,019,160	1,387,105	56,248,332
	Loss	2,745,397	1,732,732	1,776,917	5,988,154	245,808	12,489,008
	Percent loss	3.25%	2.05%	2.10%	7.09%	0.29%	14.79%
In-the-money	No. of series	237	95	44	90	42	508
	Value	98,177,185	17,388,515	14,394,613	66,314,600	11,222,208	207,497,120
	Loss	2,650,887	1,386,077	1,356,137	7,678,862	981,008	14,052,970
	Percent loss	3.14%	1.64%	1.61%	9.09%	1.16%	16.64%
All moneyness	Percent loss	6.95%	4.21%	6.07%	24.42%	3.41%	45.06%

Values and losses are computed as of close on 26 February 2018. Option prices and open interest are from the Cboe EOD quotes files. At-the-money options are defined as those whose exercise prices are within 20 percent of the closing ETP price, 13.5.

theoretical valuation standpoint, outstanding option contracts would immediately revert to their intrinsic values and the options should be exercised immediately. What is the practice? On 20 March 2020, the OCC announced that the final cash settlement at the intrinsic values would be effective 30 March 2020[12] and that the expiration dates of outstanding contracts would be accelerated. Theory and practice are one and the same. No harm, no foul. The question that follows immediately is why should other leverage ratio changes and their effects on option value be handled differently? On 26 February 2018, ProShares reduced the leverage ratio of UVXY by 25 percent and the leverage ratio of SVXY by 50 percent. Why were no contract adjustments made? Assessing economic impact is simply a matter of applying commonly accepted option valuation techniques.

Finally, one might argue that the change in leverage ratio is like a change in capital structure change where OCC bylaws state that adjustments will not be made. The analogy is inappropriate, however. Dramatically large, quick and unanticipated announcements in capital structure are rare. In addition, such changes would undoubtedly involve consultation with major shareholders and consideration of existing debt covenants. But suppose these conditions are met. In the interest of fairness, appropriate contract adjustments should be made because management is transforming the underlying security in a fundamental and deliberate way. Indeed, the OCC bylaws recognise that adjustments may be warranted if the underlying security is changed into 'another security, cash or other property'.[13] As we have argued, and as ProShares and the OCC have explicitly (or, at least, implicitly) recognised years ago, they are different securities and different option classes.

4.3. Assessing change in value

With the pre-announcement values of the outstanding option series in hand, we now turn to estimating the changes in value due to the announcement of the leverage ratio reductions announced four hours later. The procedure is based on standard BSM option valuation mechanics. As was noted earlier, if the benchmark index underlying the ETP has an expected price appreciation rate of μ and volatility rate of σ, a levered or inverse fund will have an expected price appreciation rate of $L\mu$ and volatility of $|L|\sigma$. In a risk-neutral world, the expected rate of price appreciation is the risk-free rate less the income rate. In this case, the income rate is the borrowing fee (or, equivalently, the lending rate) of the underlying ETP. For a typical stock, the borrowing fee is near zero. The general collateral (GC) rate is about 20–25 basis points. For hard-to-

[12]OCC Information Memo #46657.

[13]OCC Bylaws, Adjustments for Stock Option Contracts, Section 11A, ... Interpretations and Policies:.04.

borrow securities, which UVXY and SVXY sometimes are, the fee may be substantially higher. The effect of a leverage ratio change on option value can be assessed by valuing the different option series before, and then after, the leverage ratio reduction.

With the value of each outstanding option series in hand, we now compute the economic losses incurred by not making appropriate option contract adjustments. Based on the end-of-day option prices, we invert the option valuation formula and compute the implied volatility of each option series.[14] Then, based on the implied volatility, we revalue the option series using the same formula, but with the new leverage ratio. Since we are applying the same model transformation in computing implied volatility as we are in valuing the option after the leverage ratio change, model mis-specification becomes less important. In essence, we are simply scaling down the time value of the option. Issues regarding recognising early exercise premiums and differential borrowing and lending rates become secondary. In the event that the midpoint of the option series' price quotes is below the option's intrinsic value (as is sometimes the case for deep in-the-money and deep out-of-the-money options), the volatility rate has no effect on value, and we register no change in value (loss).

Tables 4 and 5 are prepared under the assumptions that options are fairly valued using the BSM European-style call and put option valuation formulas, the ETP is not hard-to-borrow (securities lending rate is 0 percent), and the risk-free rate equals the promised return on a Eurodollar time deposit with a maturity equal to the time to expiration of the option. Table 4 contains the results for UVXY options and Table 5 for the SVXY options. The top of Table 4 has a summary panel for the UVXY options. In all, there were 1,448 option series as of the close on 26 February 2018 – an equal number of calls and puts. The aggregate value of these options as of the close was $US463.2 million, as was noted earlier. Based on the bid/ask midpoint of each series, an implied volatility is computed. This implied volatility is then used to value the option at the reduced leverage ratio. The estimated aggregate loss across all long option holders is $US84.5 million (18.2 percent of value), with the shorts capturing the loss. A comparable summary panel for SVXY options appears in Table 5. SVXY had 2,158 option series as of the close on 26 February 2018, and the aggregate value of these options as of the close was $US265.5 million. The estimated aggregate loss (gain) for existing long (short) option holders is $US31.8 million (12.0 percent of value). Across both option classes, the total

[14]Computing implied volatilities on a series-by-series basis accounts for the empirical phenomenon of implied volatility 'smiles' and/or 'smirks' that have frequently appeared in the literature.

Table 5
Analysis of SVXY option losses as a result of absolute reduction in leverage ratio from –1 to –0.5

		All			Call		Put
No. of series		2,158			1,079		1,079
Aggregate value		265,541,404			44,370,508		221,170,896
Aggregate loss		31,825,464			16,566,582		15,258,882
Percent loss		12.0%			37.3%		6.9%
		Days to expiration					
	Days ≥	0	30	91	182	365	
	Days <	30	91	182	365	730	All days
Panel A: Call options							
In-the-money	No. of series	45	25	10	22	10	112
	Value	1,017,980	527,883	1,624,133	13,573,398	1,817,890	18,561,283
	Loss	36,940	43,573	211,042	1,701,473	420,900	2,413,929
	Percent loss	0.12%	0.14%	0.66%	5.35%	1.32%	7.58%
At-the-money	No. of series	34	30	6	13	6	89
	Value	5,503,608	1,415,839	1,938,812	6,957,866	2,672,980	18,489,104
	Loss	1,715,425	555,054	977,139	3,326,078	1,247,264	7,820,959
	Percent loss	5.39%	1.74%	3.07%	10.45%	3.92%	24.57%
Out-of-the-money	No. of series	388	59	138	212	81	878
	Value	345,917	110,043	586,174	3,817,342	2,460,648	7,320,123
	Loss	345,617	109,138	538,819	3,358,038	1,980,083	6,331,694
	Percent loss	1.09%	0.34%	1.69%	10.55%	6.22%	19.90%
All moneyness	Percent loss	6.59%	2.22%	5.43%	26.35%	11.46%	52.05%

(continued)

Table 5 (continued)

		Days to expiration					
	Days ≥	0	30	91	182	365	
	Days <	30	91	182	365	730	All days
Panel B: Put options							
Out-of-the-money	No. of series	45	25	10	22	10	112
	Value	317,726	149,083	679,935	1,987,507	470,016	3,604,265
	Loss	312,460	142,239	642,329	1,537,460	340,612	2,975,099
	Percent loss	0.98%	0.45%	2.02%	4.83%	1.07%	9.35%
At-the-money	No. of series	34	30	6	13	6	89
	Value	973,745	491,338	570,335	2,106,635	334,855	4,476,907
	Loss	594,139	221,180	281,964	979,943	172,776	2,250,001
	Percent loss	1.87%	0.69%	0.89%	3.08%	0.54%	7.07%
In-the-money	No. of series	388	59	138	212	81	878
	Value	18,520,687	3,200,735	15,166,640	161,089,558	15,112,105	213,089,725
	Loss	8,424	8,337	112,632	9,097,992	806,397	10,033,782
	Percent loss	0.03%	0.03%	0.35%	28.59%	2.53%	31.53%
All moneyness	Percent loss	2.88%	1.17%	3.26%	36.50%	4.15%	47.95%

Values and losses are computed as of close on 26 February 2018. Option prices and open interest are from the Cboe EOD quotes files. At-the-money options are defined as those whose exercise prices are within 20 percent of the closing ETP price, 13.625.

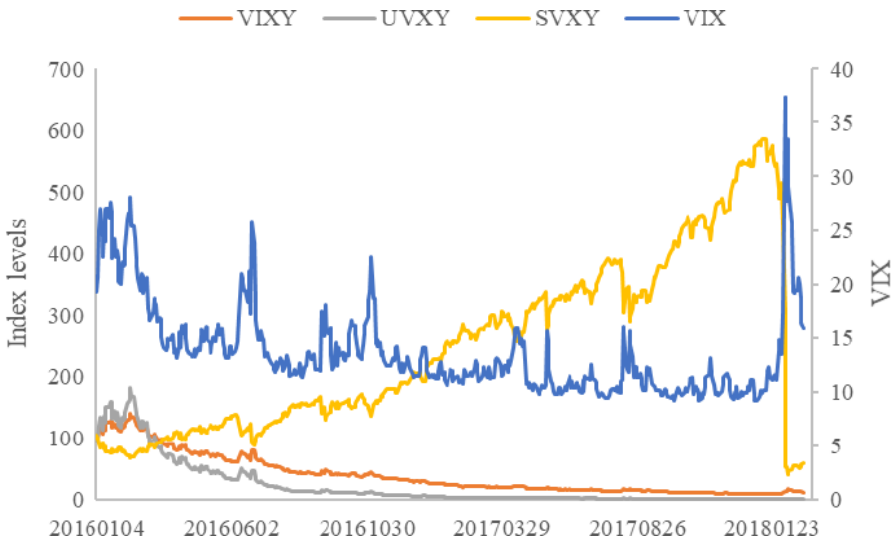

Figure 1 Daily VIX and VIX ETF index levels during the period 4 January 2016–26 February 2018. VIX levels are unadjusted. VIX ETFs are normalised to a level of 100 on 4 January 2016.

losses are $US116.3 million, only modestly higher than the $US100 million lower bound conjectured by Macro Risk Advisors one day after the OCC's no contract adjustment announcement Infomemo.[15]

Tables 4 and 5 also contain breakdowns of the aggregate values/losses by option moneyness and days to expiration. The at-the-money category is defined as those option series whose exercise prices are within 20 percent of the closing stock price. The in-the-money and out-of-the-money option categories fall on either side. While not reported in the tables, the range of exercise prices is unusually large, particularly for SVXY. The reasons are threefold: (a) the benchmark index fell significantly during the period, (b) return volatilities were high, and (c) the leverage ratios exacerbate matters further. Figure 1 shows the daily price levels of VIX and the three ProShares ETFs benchmarked to the SPVXSP during the period 4 January 2016 to 26 February 2018. VIXY fell by −88.7 percent during the two-year period as a result of the contango trap.[16] UVXY fell even further, by −99.6 percent, due to its leverage factor, 2*x*. Since

[15]'Options traders lost big from tweak in short volatility ETPs: Strategists,' *Business News* (28 February 2018) by Saqib Iqbal Ahmed reports Pravit Chintawongvanich, head of derivatives strategy at Macro Risk Advisors in New York, as saying that traders who owned UVXY and SVXY options lost at least $US100 million.

[16]The SPVXSP index level is expected to fall through time as a result of the imbalance of long hedger and short hedger demands in the VIX futures market. See Pessina and Whaley (2020).

option exchanges ensure that there are option exercise prices both above and below the prevailing security price, the range of exercise prices expands as the security prices move by large amounts in either direction. By 26 February 2018, UVXY had 122 different exercise prices ranging from 1 to 91, with exercise price increments being as little as 0.50. For SVXY options, the situation was even more dramatic. As the figure shows, SVXY rose by nearly 500 percent at one point during the time series, all the while having new exercise prices introduced. By the end of the time series, the holding period return was −42.2 percent, expanding the range on the lower end of the range. By 26 February 2020, SVXY had 276 different option exercise prices, ranging from 1 to 265.

Table 4 reports that there are 508 out-of-the-money UVXY calls, 106 at-the-money calls, and 110 in-the-money calls. This is consistent with the observed UVXY price behaviour during the sample period – a slow, but steady, decline. In the table, options are also subcategorised by days to expiration. On 26 February, UVXY had 12 different expiration dates, ranging from 4 days to expiration to 690. Longer term options (or leaps) are popular with both UVXY and SVXY options as investors appear to want long-term positions on volatility. In particular, look at the aggregate value of the options expiring in the 182–365 days category relative to the others. But such long-term options have substantial time value, and, hence, relatively larger losses with leverage ratio reductions. As the table shows, 32.5 percent of total UVXY losses by long option holders ($US84.5 million) were from calls and 24.4 percent were from puts.

Table 5 shows similar behaviours for SVXY options. Because of the unusual behaviour of the price of SVXY shown in Figure 1, higher and ever higher exercise prices were introduced. Then, on 5 February 2018, the 'wheels came off' with the spike upward in VIX and SPVXSP and the collapse of XIV, SVXY's sister $-2x$ fund. With the precipitous decline in the price of SVXY, many calls (puts) were left out-of-the-money (in-the-money). Table 5 shows 878 out-of-money call option series versus 89 at-the-money and 112 in-the-money and the opposite for puts. The popularity of longer-term options appears again. Call options with between 182 and 365 days to expiration account for 26.4 percent of the total SVXY losses of $US31.8 million, and put options with similar expirations account for 36.5 percent. In other words, those affected most by the OCC's no contract adjustment decision are those who planned to hold their VIX-related price exposure for a long period of time.

The magnitude of the economic loss from the UVXY/SVXY leverage ratio reduction is relatively insensitive to the early exercise premium and the borrowing fee. Table 6 includes the results of robustness tests. Under the 'European, analytical' columns, we use the BSM option valuation formulas but vary the borrowing rate from 0 percent to 10 percent. The 0 percent results are consistent with Tables 4 and 5. The total economic loss is $US116.3 million, or 16.0 percent of pre-announcement value. As the borrowing fee rises, the economic losses fall for UVXY options, but rise for SVXY options. The net

Table 6
Sensitivity of windfall loss to results to different valuation assumptions

Borrowing fee	European, analytical				American, binomial			
	UVXY	SVXY	Total	Percent	UVXY	SVXY	Total	Percent
0%	84,450,609	31,825,461	116,276,070	16.0	84,279,726	29,327,062	113,606,788	15.6
1%	84,023,882	32,247,774	116,271,656	16.0	83,852,007	29,429,074	113,281,081	15.5
2%	83,466,950	32,657,227	116,124,177	15.9	83,217,315	29,510,975	112,728,290	15.5
3%	82,794,808	33,052,341	115,847,149	15.9	82,687,996	29,583,689	112,271,685	15.4
4%	81,954,337	33,433,858	115,388,195	15.8	82,169,204	29,643,730	111,812,934	15.3
5%	81,131,071	33,814,669	114,945,740	15.8	81,656,034	29,705,922	111,361,956	15.3
6%	80,288,980	34,168,952	114,457,932	15.7	81,122,107	29,731,821	110,853,928	15.2
7%	79,375,035	34,509,662	113,884,697	15.6	80,843,533	29,700,122	110,543,655	15.2
8%	78,467,801	34,560,498	113,028,299	15.5	80,341,959	29,379,497	109,721,456	15.1
9%	77,451,580	34,940,234	112,391,814	15.4	79,840,622	29,392,427	109,233,049	15.0
10%	76,657,733	35,308,643	111,966,376	15.4	79,342,680	29,399,358	108,742,038	14.9

effect is a reduction in loss as the borrowing fee goes up. The set of columns under the heading 'American, binomial' are generated in the same manner as before, however, the options are valued using the binomial method of Cox, Ross and Rubinstein (1979), hereafter 'CRR'. UVXY and SVXY options, after all, are American-style. The results shown in Table 6 show that explicitly accounting for the early exercise premium does not matter much. Losses are only a few million less.

One way in which our estimates of SVXY losses may be challenged, however, is as follows. If the SPVXSP is lognormally distributed, UVXY is also lognormal. Hence, our estimates of long UVXY option losses, which are computed under the usual BSM mechanics, are fine. If SPVXSP is lognormal, however, the price of SVXY is complementary to the lognormal. Hence, the losses for the long SVXY option holders are misstated. Handling this problem is no great challenge, either analytically or numerically. If $L < 0$, value calls as if they are puts, and value puts as if they are calls. Under the assumption that SVXY is lognormally distributed, the CRR binomial method produced a loss of \$US31.8 million for long SVXY option holders. Assuming SVXY has a complementary lognormal distribution, the loss is \$US37.8 million, 18.9 percent higher. Different modelling assumptions will produce different results. The point is that a large reduction in the leverage ratio will induce large windfall gains/losses, and this fact should not be ignored.

Another possible criticism is that changes in the leverage ratio are rare events, and developing a fair contract adjustment is not worth the effort. It is unlikely that the long UVXY/SVXY option holders would agree, with aggregate losses exceeding \$US100 million. And more losses have been incurred. With the increased market volatility resulting from COVID-19, they have become all too frequent. On 27 March 2020, the OCC released Infomemo #46703 and announced that ten Direxion funds would change their leverage ratios from long/short $3x$ to long/short $2x$. The precedent, 'No contract adjustment for the change in investment policy', was again applied. At the same time, the OCC announced in a sequence of Infomemos[17] that four of ProShares' long and short $3x$ funds on crude oil and the Nasdaq Biotechnology Index would be changed as a result of a change in investment policy – a liquidation. In these instances, the leverage ratio is reduced by 100 percent (or to $0x$), and the theoretical option values become their intrinsic values (i.e., their model values assuming a volatility rate of 0 percent). Partially reducing the leverage ratio should be handled no differently. The mechanics are the same. In the interest of fairness, contract adjustments should be made.

[17]See OCC Infomemos #47635, #46736, #46737, and #46738.

5. Timing of announcements

No one disagrees with the premise that the option contract adjustments should be made in a such a way that neither long nor short option holders suffer economic loss when a fundamental change in the underlying security takes place. In the UVXY/SVXY case, the fundamental change was ProShares's surprise announcement that the funds' leverage ratios would change, and the economic loss was about $US116.3 million, where the loss was incurred by long option holders to the benefit of the short option holders as a result of the OCC's no-adjustment decision. One might be tempted to argue that the wealth transfer between UVXY/SVXY option longs to the shorts may have been exacerbated by the fact that the announcement of the leverage ratio change was a surprise. Neither shareholders nor option holders were given advance notice.[18] But this argument lacks merit.

In what seems to be the first instance of a leverage ratio change affecting option holders, Direxion in 2011 increased the leverage ratios to take a more aggressive risk posture. The announcement of the change in investment policy was handled quite differently, however. On 12 August 2011, Direxion published a supplement to their Prospectus and Statement of Additional Information (SAI) dated 13 June 2011 announcing that ten of its levered and levered inverse funds would have their ratios increased from $2x$ to $3x$ effective 11 October 2011. Their motivation was spelled out clearly. 'Because the Funds will seek to magnify the daily performance of the underlying indexes and benchmarks to a greater degree under their new investment objectives, each Fund will have the potential for greater gains, but will also be subject to the risks of greater losses for the Funds relative to the benchmark performance'.[19] On 21 September 2011, Direxion published a second Supplement stating the new effective date was 1 December 2011. Four of the ten Direxion funds had options listed on them: Gold Miners (NUGT and DUST) and Natural Gas (GASL and GASX) ETFs. The OCC refers to Direxion's 12 August 2011 Supplement in making its decision. They refer to it in their 29 September 2011 Infomemo #29538 in which they stated 'No contract adjustment for the change in investment policy'. From initial public awareness to OCC implementation, there was a total of 111 days. In contrast, the ProShares lead time was a single day.

The long gestation period of Direxion's news is of little relevance, however. The rationale is as follows. If the option market had no awareness as of 29 September 2011 that the OCC would pronounce no change to outstanding option contracts from the leverage ratio change, existing long positions in options with expiration dates beyond 1 December 2011 experienced an

[18]Extraordinary trading profits could be earned by having advance knowledge of the announcement.

[19]OCC Infomemo #29538.

immediate windfall gain at the expense of the shorts. And, as of the close of trading on 28 September 2011, 91.6 percent of the market value of the outstanding Direxion options had expiration dates beyond 1 December 2011. On the other hand, if the option market was clairvoyant and somehow anticipated with perfect certainty that the OCC would pronounce 'no-adjustment', then the windfall transfer would have occurred on 12 August 2011, or before if the market became informed the supplement was published. One reason why the Direxion change in leverage and its effect on option markets may not have been noted in the press is that this was uncharted territory, and the value of NUGT, DUST, GASL and GASX options together was less than $US14 million, as shown in Table 7. The windfall wealth transfer from the shorts to the longs would have been on order of $US2 million, hardly enough to attract the attention of the financial press. But, at the $US116 million associated with the ProShares UVXY/SVXY controversy, bells and whistles should have sounded. As noted earlier, ProShares believed that its quick decision and immediate implementation was 'in the best interests of the funds and their shareholders'. In terms of welfare of the UVXY and SVXY option holders, ProShares distanced themselves by saying 'The Options Clearing Corporation issues and clears US-listed options. Neither ProShares Capital Management nor funds issue or sponsor options'. Whether they knew or anticipated the OCC's no-adjustment precedent seemed to be, in their minds at least, irrelevant.

6. A simple contract adjustment proposal

Thus far, we have reviewed the OCC's role in adjusting the terms of outstanding option contracts when certain types of corporate actions take place. We then analysed a new type of corporate action – changes to the leverage ratio of levered and inverse funds. What is unusual about this particular case is that the OCC made no adjustments to the terms of outstanding option contracts. Not only has this created large windfall transfers of wealth between option buyers and sellers, but also will continue to create the same inequities as the pace of ETP leverage ratio reductions accelerates. We now move from why contract adjustments should be made to how they might be done.

In making adjustments to existing option contracts, the OCC has at least four degrees of freedom – the exercise price, the expiration date, the number of option contracts and the unit of trading. We consider each in turn. First, we can change the exercise price of each option series by an absolute or proportional amount as was done for special cash dividends. Presumably, that would involve reducing the exercise price of the call and increasing the exercise price of the put to compensate the long option holders for their windfall loss. A problem with this approach is that changing the exercise price without there being a commensurate change in the price of the underlying security (as there

Table 7
Comparison of size of existing option positions on the day before OCC announced contract adjustment terms for Direxion's and ProShare's decisions to change leverage ratio of levered and levered inverse funds

Direxion ETF	28 September 2011 Number of series	Market value of open interest	ProShares ETF	26 February 2018 Number of series	Market value of open interest
GASL	302	3,228,053	UVXY	1,448	463,182,256
GASX	168	1,005	SVXY	2,158	265,541,404
NUGT	226	5,109,628			
DUST	188	5,466,355			
Total		13,805,040	Total		728,723,660
Factor difference					52.8

was in the special cash dividend case) changes the option's moneyness (i.e., ratio of forward price to exercise price), and hence the probability that it will be in-the-money at expiration. It has entirely different return/risk characteristics than it had before.

Second, we can change the expiration date of the option. This alternative is used rarely and usually involves an acceleration of the expiration to present day. In this case, however, the time to expiration would have to be extended, with the extra time premium compensating the existing option buyers for the windfall loss in option value. While this would approximately preserve the moneyness of the option and the probability that it will be in-the-money at expiration, there is the practical matter that each option series would have a new expiration date. Managing a continuum of expiration dates would be a nightmare for most option trading platforms.

Third and fourth, we could either (a) increase the number of option contracts, or (b) increase the number of deliverable shares. While the reduction in the leverage ratio reduces drift and volatility, the reduction in option value would be compensated by a quantity of options or more deliverable shares of each contract. Under the first alternative, the number of option contracts for each option series would change by a factor of m, where m is the solution to

$$C(\mu, \sigma) = m \times C(L\mu, |L|\sigma) \tag{2}$$

Under the second alternative, the number of new deliverable shares for each option series is the solution for n in the following equation,

$$100 \times C(\mu, \sigma) = (100 + n) \times C(L\mu, |L|\sigma). \tag{3}$$

These two approaches are equivalent from a theoretical perspective. Naturally, both m and n would need to be whole numbers, which would lead to some minor imprecision. Each option series would have a different value for m or n, but that is simply a bookkeeping matter.

The key elements of this simple contract adjustment procedure are as follows:

1 Option valuation method: We applied different valuation methods and different borrowing rates. The amount of the losses varied only modestly. Since the levered and inverse options are American-style, the CRR binomial method makes the most sense. Accounting for the complementary lognormal distribution in the valuation of options on inverse funds is best from a theoretical perspective.
2 Borrowing rate: Finding an appropriate borrowing rate for the ETP is problematic. The securities lending market is opaque. Finding two-sided quotes for the overnight rate is difficult. Finding two-sided quotes for the term structure of borrowing rates is virtually impossible. Assuming a borrowing rate of 0 percent until such time as reliable and readily transparent rates become available seems appropriate.
3 Exclusions:

   a No contract adjustment for series with no open interest.
   b No contract adjustment for series whose bid/ask midpoint is below the intrinsic value of the option. The option has no time value.
   c No contract adjustment for series with zero bids.

Refinements will be required before settling on a final procedure, but that is beyond the scope of our paper. Ours was simply to demonstrate that no contract adjustment is unfair, and that standard BSM option valuation mechanics can be applied to design a contract adjustment procedure that seems both easy to implement and equitable.

7. Conclusion

Levered and inverse funds on stocks, bonds, commodities and volatility are actively traded in the US. So actively, in fact, options on these funds are now commonplace. Of the 277 ETPs traded in the US, 122 (44 percent) have listed options. A problem has arisen in these option contract markets, however. With increasing frequency, ETP issuers are reducing their leverage ratios. Ten occurred in March 2020 alone. Reducing leverage ratios reduces option values, causing windfall gains/losses between existing short/long option holders. Because the OCC does not adjust the terms of existing option contracts to reflect the change in option values arising from these leverage ratio changes, the gains/losses become permanent. We show that in a single unanticipated announcement of the leverage ratio changes of two funds, more than $US100

million in long option holder wealth was transferred to the shorts permanently. We offer a simple contract adjustment procedure that would help prevent such unfair transfers.

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