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### Writing covered calls

Groot, J.S. de; Dijkstra, T.K.

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# 1. Introduction

Shefrin and Statman (1993) discussed behavioral aspects of the design and marketing of financial products. In particular, they focussed on the case of writing covered calls: writing call options on stock in possession. Their analysis is based on prospect theory. This implies that the choice process is divided into two sequential operations. First is the creation of mental accounts by a framing process. Second is the application of a valuation rule to these mental accounts.

The following example of mental accounting and framing applied to writing out-of-the-money covered calls is taken from a manual for stockbrokers by Gross (1988). It states that writing covered calls leads to three sources of profit:

First, you could collect a lot of dollars - maybe hundreds, sometimes thousands - for simply agreeing to sell your just-bought stock at a higher price than you paid. This agreement money is paid to you right away, on the very next business day - money that's yours to keep forever. Your second source of profit could be the cash dividends due you as the owner of the stock. The third source of profit would be in the increase in price of the shares from what you paid, to the agreed selling price.

By agreeing to sell at a higher price than you bought, all you are giving up is the unknown, unknowable profit possibility above the agreed price. In return, for relinquishing some of the profit potential you collect a handsome amount of cash that you can immediately spend or reinvest, as you choose. (Gross (1988), p.244)

Shefrin and Statman (1993) used a one period, binomial example to support their arguments about the attractiveness of writing covered calls and to provide several hypotheses. They offered three hypotheses concerning the writing of covered calls:

- (i) More covered call positions are formed with out-of-the-money calls than with in-the-money calls.
- (ii) More covered call positions are fully covered than partially covered.
- (iii) Relative to the prescriptions of standard finance, investors with covered call positions are reluctant to repurchase the call when the purchase entails the realization of a loss.

The remainder of this paper is organized as follows. Section 2 describes mental accounting and framing and the model used: the cumulative version of prospect theory. Section 3 provides

an implementation of the model on Shefrin and Statman's examples. Section 4 seeks to find confirmation for the three hypotheses. Section 5 outlines some extensions. Section 6 concludes.

## 2. The model

### 2.1 Introduction

The starting point of our analysis is an investor with a normalized asset position of one share of stock. The investor's asset position can be normalized, because we assume that the investor's decisions only depend on returns.<sup>1</sup> Given his stock-only position, the investor can create an extra return by writing a fraction of  $\alpha$  calls ( $\alpha > 0$ ). At first, we assume that this return is used for additional consumption and, consequently, evaluated separately.<sup>2</sup> Later on, we look at an investor who reinvests the call premium.

The model we use to evaluate different positions is the cumulative version of prospect theory. According to Tversky and Kahneman (1992), prospect theory distinguishes two phases in the choice process: *framing* and *valuation*. In the framing phase, the decision maker constructs mental accounts: a representation of the outcomes that are relevant to the choice process. In this paper, we focus on the *hedonic framing* framework of Thaler (1985). In the valuation phase, the decision maker assesses the value of each separate mental account and chooses accordingly. The prospect theory value function is thus applied to framed prospects.

### 2.2 Cumulative Prospect Theory

In the classical expected utility theory, the utility of a financial product with cash flows contingent on events and the passage of time is the sum of the utilities of the outcomes, each

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<sup>1</sup> The assumption that the investor's decisions, which are based on his preference order, only depend on returns follows logically from the fact that we assume that the investor evaluates choices with a prospect theory value function. In note 9 we show that, in this setting, his preference order *indeed* only depends on returns.

<sup>2</sup> Shefrin and Statman (1984) suggested that dividends fall into the income account, while stock falls into the asset account. According to Shefrin and Thaler (1988), this results in a separate evaluation of dividends and stock. As Shefrin and Statman (1993) stated, the call premium received can be framed as an extra dividend.

weighted by its probability. Standard theories of finance maintain that economic subjects are indifferent among frames of cash flows: when a package of cash flows is split up and rebundled without affecting the net cash flow, the value of the package remains unchanged. Contrary to these theories, descriptive theories of choice behavior, such as prospect theory, do not assume frame invariance. Empirical evidence<sup>3</sup> confirms the rejection of the assumption of frame invariance.

Prospect theory makes two major modifications to expected utility theory: (i) prospects are evaluated according to gains and losses, not final assets; and (ii) the value of each outcome is multiplied by a decision weight, not by an additive probability. So, the prospective value of a prospect which pays off  $x_i$  with probability  $p_i$  is given by

$$V(\cdot) = \sum \pi_i \cdot v(x_i), \quad (1)$$

where  $\pi_i$  is the decision weight associated with outcome  $i$  and  $v(x_i)$  is the prospective value of  $x_i$ .

Prospect theory investors, as opposed to expected utility investors, evaluate their choices with an S-shaped value function and two inverse S-shaped weighting functions for the probabilities of the outcomes. The two parts of the value function imply risk-averse behavior in the domain of gains and risk-seeking behavior in the domain of losses. The value function is normalized by a reference point; the value of the status quo is zero and gains and losses are relative to this reference point. Tversky and Kahneman (1992) provided a two-parameter expression for the value function and parameter estimates:

$$v(x) = \begin{cases} x^\alpha & \text{if } x \geq 0 \\ -\lambda \cdot (-x)^\alpha & \text{if } x < 0. \end{cases} \quad (2)$$

The parameter  $\lambda$  captures empirically observed *loss aversion* and is estimated as 2.25 while  $\alpha$  is estimated as 0.88.<sup>4</sup> Figure 1 below shows the prospect theory value function for these parameter estimates.

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<sup>3</sup> See, e.g., Tversky and Kahneman (1992) or Quiggin (1993).

<sup>4</sup> If  $v(x) = x^\alpha$ , then  $v'(x) = \alpha \cdot x^{\alpha-1}$  and  $v''(x) = \alpha \cdot (\alpha - 1) \cdot x^{\alpha-2}$ , such that  $\frac{-x \cdot v''(x)}{v'(x)} = 1 - \alpha$ . So  $\alpha$  equals 1 minus the coefficient of relative risk aversion in expected utility theory.

**FIGURE 1: HERE**

Cumulative prospect theory uses decision weights that depend on the objective probability of an outcome and the rank-order of all outcomes.<sup>5</sup> Furthermore, the weights are different for outcomes that are framed as gains and those that are framed as losses. The inverse S-shape implies that small probabilities are overweighted while moderate and high probabilities are underweighted. Figure 2 below shows these weighting functions. The less curved weighting function refers to losses and the more curved weighting function refers to gains.

**FIGURE 2: HERE**

### 2.3 *Mental accounting and hedonic framing*

Before the prospect theory value function can be applied, the outcomes, i.e. the returns on the covered call positions, have to be framed into different mental accounts. Thaler (1985) discussed hedonic framing: alternative frames of mental accounts lead to different prospective value. An investor who applies hedonic framing frames outcomes such that prospective value is maximized.

In our analysis, the covered call position can result in a maximum of three different returns:<sup>6</sup> a strictly positive return resulting from receiving  $\alpha$  times the call premium at  $t = 0$ , i.e.  $\alpha \cdot R_0 = \alpha \cdot \frac{C_0}{S_0}$ , the return on the stock resulting from an appreciation or depreciation of the stock price, i.e.  $R_s = \frac{S_T - S_0}{S_0}$ , and, if  $S_T > X$  (the exercise price), a strictly negative return resulting from writing  $\alpha$  calls per share, i.e.  $\alpha \cdot R_c = \alpha \cdot \left( \frac{S_T - X}{S_0} \right)$ . Because the investor receives the call premium with certainty at  $t = 0$  while he receives the other returns at  $t = T$ ,  $\alpha \cdot R_0$  is always evaluated separately. However, the stock return  $R_s$  and the covered call return  $\alpha \cdot R_c$  can be evaluated separately or jointly, depending on the prospective value of segregation and integration. A joint outcome  $(x, y)$  is valued jointly if the prospective value of integrating these outcomes,  $v(x + y)$ , exceeds the prospective value of separating

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<sup>5</sup> The functional form of the weighting functions, the relation between the weighting function and the cumulative distribution function, and the relation between the weighting functions and the decision weights can be found in appendix 1.

<sup>6</sup> We assume that the stock pays no dividend.

the outcomes,  $v(x) + v(y)$ . The S-shape of the prospective value function determines the optimal framing rule. The following four situations can be distinguished:<sup>7</sup>

- Multiple gains:  $(x, y)$ . If both outcomes are positive, the concavity of  $v(\cdot)$  implies that  $v(x) + v(y) > v(x + y)$ , so segregation is preferred for multiple gains.
- Multiple losses:  $(-x, -y)$ . Since  $v(\cdot)$  is convex for losses,  $v(-x) + v(-y) < v(-(x + y))$ , so multiple losses should be integrated.
- Mixed gains:  $(x, -y)$ . If the separate outcomes have the opposite sign and the gain,  $x$ , is larger than the absolute value of the loss,  $y$ ,  $v(x) + v(-y) < v(x - y)$ , so integration is preferred for mixed gains. In the case of a net gain, integration amounts to *cancellation*.
- Mixed losses:  $(x, -y)$ . If the separate outcomes have the opposite sign and the gain is smaller than the absolute value of the loss,  $v(x) + v(-y) <> v(x - y)$ , such that both integration and segregation could be optimal in the case of a net loss. If  $x \ll y$ , it is likely that  $v(x) + v(-y) > v(x - y)$ , such that segregation is preferred. This is called *silver lining*. However, if  $x \approx y$ , it is likely that  $v(x) + v(-y) < v(x - y)$ , such that integration is preferred.

In appendix 2, hedonic framing is applied to the writing of covered calls. This appendix shows that it is optimal to integrate the joint outcome  $(R_s, -\alpha \cdot R_c)$  in all but one situation. Only if the positive stock return is sufficiently small relative to the absolute value of the negative covered call return, silver lining could be optimal.

### 3. Implementation

Shefrin and Statman (1993) used a one period, binomial example to support their arguments and to provide several hypotheses concerning the writing of covered calls. In their examples, the price of a share one period from now could be twice as high ( $S_T = 40$ ) or half as high ( $S_T = 10$ ) as today's price ( $S_0 = 20$ ). These stock prices determine the value of a call option on this share in the up state and the down state. Because the exercise price ( $X$ ) is assumed to be 35, the value of the call is 5 in the up state and 0 in the down state. If it is assumed that the risk-free interest rate is zero, it can easily be verified that the price of this call at  $t = 0$  is 1.67. This price is based on standard arbitrage arguments. This price

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<sup>7</sup> For all situations, both  $x$  and  $y$  are strictly positive.

does not depend on the objective probabilities of the up and down state. Now, a covered call position can be compared with other positions, such as a stock-only position, with identical cash flows. Shefrin and Statman focussed on comparing positions with identical cash flows to disentangle framing effects from the effects of attitudes toward risk. If the prospective value of products with identical cash flows, and therefore identical 'risk', differs, the assumption of frame invariance should be rejected.

If we compare a covered call position with a stock-only position, the following could be noted. The prospective value<sup>8</sup> of the stock-only position is:<sup>9</sup>

$$\frac{1}{2} \cdot \left[ v \left( \frac{40 - 20}{20} \right) + v \left( \frac{10 - 20}{20} \right) \right],$$

while the prospective value of the covered call position is:

$$v \left( \frac{1.67}{20} \right) + \frac{1}{2} \cdot \left[ v \left( \frac{35 - 20}{20} \right) + v \left( \frac{10 - 20}{20} \right) \right].$$

The prospective value of the covered call position exceeds that of the stock-only position only when:

$$v \left( \frac{1.67}{20} \right) > \frac{1}{2} \cdot \left[ v \left( \frac{40 - 20}{20} \right) - v \left( \frac{35 - 20}{20} \right) \right],$$

or in another form:

$$v \left( \frac{1.67}{20} \right) + \frac{1}{2} \cdot v \left( \frac{35 - 20}{20} \right) > \frac{1}{2} \cdot v \left( \frac{40 - 20}{20} \right).$$

Shefrin and Statman then stated that the prospective value of the covered call position exceeds the prospective value of the stock-only position for investors who are *sufficiently* risk averse in the domain of gains. However, if we use the parameter estimates of Kahneman and Tversky

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<sup>8</sup> In this example, probability weighting is not applied. Later on, in our analysis, we will use probability weighting functions.

<sup>9</sup> In their example, Shefrin and Statman (1993) used net cash flows to evaluate different positions. In this setting, returns are used. The ratio of the prospective value of the different positions, and thus the preference order, does not change because of the form of the prospective value function. For a positive net cash flow,  $v(x) = x\alpha$ , while the prospective value of the return of this net cash flow is  $v\left(\frac{x}{S_0}\right) = \left(\frac{1}{S_0}\right)\alpha \cdot x\alpha$ . For a negative cash flow,  $v(-x) = -\lambda \cdot x\alpha$ , while the prospective value of the return is  $v\left(\frac{-x}{S_0}\right) = -\lambda \cdot \left(\frac{1}{S_0}\right)\alpha \cdot x\alpha$ . This implies that the ratio of the prospective value does not depend on the use of net cash flows or returns.

(1992), the prospective value of the stock-only position is

$$\frac{1}{2} \cdot [v(1) + v(-0.5)] = \frac{1}{2} \cdot [1^{0.88} - 2.25 \cdot (0.5)^{0.88}] \approx -0.1113,$$

while the prospective value of the covered call position is

$$v(0.0833) + \frac{1}{2} \cdot [v(0.75) + v(-0.5)] = \\ (0.0833)^{0.88} + \frac{1}{2} \cdot [(0.75)^{0.88} - 2.25 \cdot (0.5)^{0.88}] \approx -0.1108.$$

This implies that the covered call position is preferred to the stock-only position, but the status quo is preferred to both positions! The loss-aversion parameter  $\lambda$  should be much closer to zero (less loss aversion) to imply positive prospective value.

In their second example, concerning the analysis of partially covered calls, Shefrin and Statman (1992) distinguished two frames. The first frame presents the partially covered call as a fully covered call position and a position in naked calls. In the second frame, the partially covered call is seen as a position in naked shares and a position in naked calls. However, a third frame is possible as well. In their first example, Shefrin and Statman segregated the returns (cash flows) of time zero and the returns at maturity. This implies that the call premium is evaluated separately. Analogously, we can segregate the returns of time zero and at maturity in the partially covered call analysis as well. In a hedonic framing framework, this is the optimal frame because the prospective value of the position is maximized. However, if we apply the estimated functions, the prospective value of the partially covered call position is smaller than the prospective value of the fully covered call position and the stock-only position for all three frames.

Shefrin and Statman's third example concerns a comparison of writing covered calls with in-the-money and out-of-the-money call options. We find that, given Tversky and Kahneman's parameter estimates, prospective value will not be enhanced if the position is constructed with in-of-the-money rather than with out-the-money calls. If we look at a covered call position that is constructed with an at-the-money call option, which has a price of 6.67, we calculate that the prospective value of this position lies between the prospective value of the position constructed with in-the-money and out-of-the-money call options. This means that



a prospect theory investor would prefer to construct a covered call position with out-of-the-money calls and would try to avoid to construct it with in-the-money call options. However, the prospective value of all positions is still negative, which means that this investor still prefers the status-quo to all covered call positions.

The results of these examples are unsatisfactory and raise questions because the status quo is preferred to all covered call positions. So it appears that the constructed examples are somewhat unfortunate: a prospect theory investor would prefer to do nothing instead of holding stock or writing covered calls. Given real time data, we try to investigate the relevance of writing covered calls in practice; should a prospect theory investor ever write call options on stock he owns?

Abandoning a stylized situation means giving up some advantages. Contrary to the examples of Shefrin and Statman, perfect matching of cash flows will not be possible in our situation. We cannot compare products with identical cash flows because the positions we analyze are static. In a continuous state space, cash flows resulting from static positions cannot be perfectly matched unless a dynamic strategy is used. The fact that we cannot match cash flows perfectly implies that it will be harder to disentangle framing effects from the effects of attitudes toward risk. However, because the risk parameters we use are plausible, we expect that the results will be mainly the result of framing effects.

## **4. Results**

### ***4.1 Introduction***

We want to investigate whether an investor who owns shares of stock can enhance the prospective value of his stock-only position by writing call options. If the writing of covered calls can enhance prospective value, how should it optimally be done? Should an investor write fully or partially covered calls? Should he write out-of-the money or maybe in-the-money calls?

In our analysis, we use a time horizon of 1 year. This implies that all combinations of stock

and calls are evaluated according to 12-month returns. We use monthly returns on the MSCI Dutch equity index from January 1978 to June 1994; a total of 198 months. These returns show no serial correlation, so  $n$ -month returns can be simulated by drawing  $n$  monthly returns from the empirical distribution function and multiplying them. Simulated 12-month returns were used to estimate the volatility of the stock index. Because the index is a reinvestment index, the dividend yield is equal to zero. The option pricing formula of Black and Scholes<sup>10</sup> is used to calculate the call premiums.<sup>11</sup>

To calculate the prospective value of the covered call position, we sum the prospective value of the strictly positive return on the call premium and the prospective value of the return on the combined position of stock and a fraction of written calls. Of course, the call is exercised only when the stock price exceeds the exercise price.

## 4.2 *Writing covered calls*

The prospect theory investor of this article has the opportunity to write one of three possible call options on the stock index.<sup>12</sup> All call options have a time to maturity of 1 year. If we normalize the price of the stock at 1, the exercise prices of the options are set equal to 0.9, 1, and 1.1 for the in-, at-, and out-of-the-money call respectively.<sup>13</sup>

As a first observation it should be noted that an investor who uses a cumulative prospective value function prefers the status quo to both buying and selling an at-the-money call; the prospective value of both call positions is negative, while the prospective value of the status quo is zero by definition.<sup>14</sup> This result seems counterintuitive, but can be fully explained by the characteristic shape of the value function and the weighting functions: gains and losses are valued differently. Buying a call option implies giving up a sure amount of money (the call premium) at this moment in exchange for an uncertain nonnegative return in the future.

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<sup>10</sup> See, e.g., Hull (1993).

<sup>11</sup> Implicitly, we assume the call options are European.

<sup>12</sup> We are working on a more general setting with  $X = k \cdot S_0$ .

<sup>13</sup> We can normalize because we are only interested in returns and because the ratio of the call premium and the stock price is independent of a scaling factor. If  $C = call(S, X)$  and  $C_k = call(k \cdot S, k \cdot X)$ , then  $\frac{C}{S} = \frac{C_k}{k \cdot S}$ .

<sup>14</sup> However, it should be noted that the prospective value of the short position is much smaller than the prospective value of the long position.

In this situation, the certain cash outflow outweighs the uncertain cash inflow. Selling a call implies receiving a cash inflow at this moment in exchange for an uncertain cash outflow in the future. In this situation, the uncertain outflow outweighs the certain inflow. Because of loss aversion, overweighting small (cumulative) probabilities, and underweighting moderate and high (cumulative) probabilities, the cash outflows outweigh the cash inflows. This result implies that a prospect theory investor will only use at-the-money call options *in combination with other securities*.

Figure 3 below shows the prospective value of a combination of a long position in stock and fractions of written call options with a time to maturity of 1 year. The prospective value of the status quo is zero. A prospect theory investor only prefers a position to the status quo if its prospective value is positive. For  $\alpha = 0$ , the vertical axis of Figure 3 shows the (positive) prospective value of the stock-only position; the stock-only position is preferred to the status quo. So, contrary to the example of Shefrin and Statman, in this situation an investor prefers the stock-only position to the status-quo.

### FIGURE 3: HERE

As can be seen from Figure 3, a combination of stock and a short position in calls (*writing covered calls*) cannot enhance value relative to the stock-only position.<sup>15</sup> The adjustment of the simulated return distribution of the stock-only position is valued negatively for all three options. Apparently, the certain cash inflow is not high enough to compensate the extreme positive returns; the received call premium does not outweigh the, as Gross (1988) called it, unknown, unknowable profit possibility.

The observed discontinuities of the slopes in Figure 3 at  $\alpha = 1$  can be explained as follows. At  $\alpha = 1$ , the total position changes from fully covered call writing into partially covered call writing: the number of shares is not sufficient to fully cover the number of calls that are written. If the call is in-the-money at maturity, the total portfolio cash flow ( $CF_P$ ) from the

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<sup>15</sup> In our analysis, we ignore the time value of money. If we assume that the investor earns the risk-free interest rate on the call premium he receives, the changes in the results of our analysis are scarcely perceptible. Furthermore, covered call writing is generally assumed to provide extra consumption, which implies that the investor does not receive the risk-free rate on the call premium.

covered call position equals the stock price at maturity ( $S_T$ ) minus  $\alpha \cdot$  the cash flow resulting from the written call position. When cash flows are transformed into returns this results in:

$$\begin{aligned}
 R_P &= \frac{CF_P - S_0}{S_0} = \frac{(S_T - \alpha \cdot (S_T - X)) - S_0}{S_0} \\
 &= \frac{S_T - S_0 - \alpha \cdot S_T + \alpha \cdot S_0 + \alpha \cdot X - \alpha \cdot S_0}{S_0} \quad (3) \\
 &= (1 - \alpha) \cdot R_S + \alpha \cdot R_X,
 \end{aligned}$$

where  $R_X$  is defined as  $\frac{X - S_0}{S_0}$ . In general, the sign of the majority of the stock returns is positive. However, as more than one call is written per share ( $\alpha > 1$ ), this majority of returns affects the total portfolio return negatively.

Figure 3 sheds some light on Shefrin and Statman's hypotheses (i) and (ii) as well. To recall, these hypotheses stated:

- (i) More covered call positions are formed with out-of-the-money calls than with in-the-money calls.
- (ii) More covered call positions are fully covered than partially covered.

Given a fixed fraction, a prospect theory investor would construct a covered call position with out-of-the-money calls rather than with in-the-money (or at-the-money) calls. This is consistent with hypothesis (i). However, given Tversky and Kahneman's parameter estimates, this investor would never write covered calls: he prefers the stock-only position. In section 5 we investigate whether these results change if the parameters are changed or if the call premium is reinvested in additional stock.

A last observation from Figure 3 concerns Shefrin and Statman's hypothesis (ii). Figure 3 shows that an investor who uses a cumulative prospective value function, given the parameter estimates, will never write calls on stock that he does not own. As the hypothesis stated, the case of partially covered call writing is less relevant because a prospect theory investor values writing naked calls negatively.

### 4.3 *Buying calls*

An investor can combine a stock position with a long position in calls. In Figure 4 below,

the investor takes a long position in calls, so  $\alpha$ , the fraction of written calls, is negative.<sup>16</sup> Figure 4 shows that an investor who uses a cumulative prospective value function finds the combination of stock and a long position in call options less attractive than the stock-only position. This is contrary to the observation by Bookstaber and Clarke (1984) who find that in a mean-variance context a combination of stock and call options is valued higher than a stock-only position. Because of the positive correlation between the value of a call and positive returns on the stock index, a long position in calls strengthens the positive part of the distribution function of the returns at the cost of a fixed negative premium. Contrary to a mean-variance context, in a prospect theory context the combination of a long position in stock and calls is not valued positively, as could be expected by the remark above concerning the shapes of the value function and the weighting functions.

**FIGURE 4: HERE**

## 5. Extensions

In appendix 2, we applied hedonic framing to the writing of covered calls. This relates to Shefrin and Statman's hypothesis (*iii*) which stated:

- (*iii*) Relative to the prescriptions of standard finance, investors with covered call positions are reluctant to repurchase the call when the purchase entails the realization of a loss.

According to this hedonic framing framework of Thaler (1985), *integration* of the stock return and the return on the call position is optimal in all but one situation. Only when  $X < S_0 < S_T$ , and the  $R_S$  is (very) small compared to the absolute value of the return on the call position, i.e.  $\alpha \cdot \frac{(S_T - X) - S_0}{S_0}$ , *silver lining* can be optimal. This implies that, given the assumption that the investor applies hedonic framing, the prospective value given in Figure 1 above is a very good approximation of the optimal prospective value.

As could be expected, the segregation of the stock return and the return on the call position lowers prospective value in all situations. Simulations show that prospective value declines

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<sup>16</sup> In fact, Figure 4 can be read from right, the stock-only position, to left.

monotonically from the stock-only position; a prospect theory investor would never write (a fraction of) a covered call if he segregates all the returns. These results confirm Shefrin and Statman's hypothesis (iii).

It could be possible that *reinvestment* changes our results. If we assume that reinvestment is costless, the investor can reinvest  $\alpha$  times the call premium he receives in additional stock. Of course, the investor cannot consume the call premium at time zero so only returns at maturity are important. Reinvestment changes the results only slightly. Prospective value still declines monotonically, but the differences between the three option positions become clearer.

An important parameter that can be changed and that, probably, will influence the results is the time horizon. The time horizon determines the time to maturity of the call options and the shape of the simulated return distributions. As the time horizon shortens, the stock-only position still remains optimal, but the differences become less clear. When time to maturity is shortened to 1 month, it is optimal to write approximately 0.4 *at-the-money* calls. However, it should be noted that the prospective value of this position is negative, just as the value of the stock-only position.<sup>17</sup>

It is important to test the robustness of the results for changes in parameters. Simulations show that the form of the results does not significantly alter if the loss-aversion parameter or the parameters of the probability weighting functions are changed; covered call positions are optimally constructed with out-of-the-money calls but the stock-only position still has the highest prospective value. If the exponent of the power value function becomes higher, i.e. the value function begins to look like a straight line, the results are only strengthened. If the exponent of the power function is lowered significantly, e.g. from 0.88 to 0.7, writing calls becomes more attractive. With this parameter, the investor should write approximately 0.4 *out-of-the-money* call options per share. However, the optimal prospective value is only marginally higher than the prospective value of the stock-only position. The call premium

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<sup>17</sup> Benartzi and Thaler (1995) show that a prospect theory investor finds stock more attractive when the evaluation period (time horizon) lengthens. In this situation, when the evaluation period is 1 month, the status-quo is preferred to a stock-only position.

received with certainty and the negative correlation between the value of a call and positive returns on the stock index adjust the simulated return distribution of the stock-only position. In this situation, they adjust the return distribution in such a way that the prospective value of writing a fraction (out-of-the-money) calls in combination with owning stock is higher than the prospective value of the stock-only position. The value function is concave in the domain of gains, so extremely high returns are not extremely valuable. On the other hand, the call premium, collected for relinquishing some of the profit potential, is very valuable because it is received with certainty.

Tversky and Kahneman (1992) mentioned that they estimated the exponents of the power functions for gains and losses separately and that both estimates equaled 0.88. Kahneman and Tversky (1982) mentioned that, if probability weighting is neglected, the exponents of the power functions were roughly 0.67 and 0.75 for gains and losses, respectively.<sup>18</sup> If we allow for different exponents for gains and losses, our results do not change. If we lower the exponent for gains to 0.7 while the exponent for losses remains 0.88, the optimal fraction is roughly the same as when both exponents are lowered. In this situation, the prospective value of the optimal covered call position is only marginally higher than the prospective value of the stock-only position as well. However, if we also shorten the time to maturity of the options, the results do change. In this situation, even partially covered call writing becomes attractive.

Summarizing, all simulations show that our results are, in general, rather robust to changes in the parameter values that were proposed by Tversky and Kahneman (1992). We conclude that the general pattern is one where the stock-only position is preferred to a covered call position. Only for specific parameters and a relatively short time to maturity a preference for covered call writing to the stock only position can be found. These specific situations may correspond to the preferences of specific clienteles, as mentioned by Shefrin and Statman (1993). They suggested that the (overlapping) clienteles consist of investors who are highly risk-averse in gains and investors who consume from their portfolio. Our results confirm the first suggestion; high risk aversion in the domain of gains corresponds to a lower exponent of the power value function.

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<sup>18</sup> The differences between these estimates are caused by the influence of probability weighting.

## **6. Conclusions**

Writing covered calls may enhance prospective value for a prospect theory investor who uses a cumulative prospective value function for his investment decisions. However, the parameters representing his preferences should imply significantly more risk aversion than the standard parameters. Our results confirm earlier hypotheses stating that an investor should only write covered calls on stock he already owns and that investors are reluctant to repurchase call options when the purchase entails the realization of a loss. Furthermore, our results support the hypothesis that it is optimal to construct a covered call position with out-of-the-money calls rather than with in-the-money calls. However, only a small clientele may implement covered call writing.



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## Appendix 1

In prospect theory, decision weights are different for gains and losses. Furthermore, in the cumulative version of prospect theory, they depend on the cumulative distribution function,  $F(\cdot)$ , of the outcomes and not only on the probability of a single outcome. So, decision weight  $\pi_i$ , which is related to outcome  $x_i$ , depends on the sign of outcome  $x_i$  and the cumulative distribution function. In particular, the decision weight attached to a *negative* outcome  $x_i$  is:

$$\pi_i^- = w^-(F(x_i)) - w^-(F^*(x_i)) , \quad (4)$$

where  $w^-(\cdot)$  is the transformation function of the cumulative distribution function  $F(\cdot)$  and  $F^*(x_i)$  is defined as the probability of obtaining an outcome that is *strictly less* than  $x_i$ . Furthermore, the decision weight attached to a *positive* outcome  $x_i$  is:

$$\pi_i^+ = w^+(G(x_i)) - w^+(G^*(x_i)) , \quad (5)$$

where  $w^+(\cdot)$  is the transformation function related to positive outcomes,  $G(x_i)$  is defined as the probability of obtaining an outcome that is equal to or better than  $x_i$ , and  $G^*(x_i)$  is defined as the probability of obtaining an outcome that is strictly better than  $x_i$ .

Tversky and Kahneman (1992) provided a one-parameter expression for these weighting functions:

$$w(p) = \frac{p\gamma}{(p\gamma + (1-p)\gamma)^{\frac{1}{\gamma}}} . \quad (6)$$

Furthermore, they provided parameter estimates that are different for gains and losses. The parameter,  $\gamma$ , is estimated as 0.61 and 0.69 for gains and losses, respectively. Figure 2 showed these weighting functions for cumulative probabilities.

## Appendix 2

In this appendix, it is assumed that  $\alpha \in [0, 1]$ , so no more than one call could be written per share. Furthermore,  $X \in \{0.9 \cdot S_0, S_0, 1.1 \cdot S_0\}$  such that the covered call position can be constructed with an in-the-money, at-the-money, and out-of-the-money call respectively. This leads to the following three situations concerning the (multiple) outcome  $(R_S, -\alpha \cdot R_C)$ :

1.  $X = 0.9 \cdot S_0$ .

(a)  $S_T < X < S_0$ .

This implies that  $R_P = R_S - \alpha \cdot R_C = R_S < 0$ .

(b)  $X < S_T < S_0$ .

This implies that  $R_P = R_S - \alpha \cdot R_C = R_S + \widetilde{R}_C$ ,

with  $R_S < 0$ ,  $R_C > 0$ , so  $\widetilde{R}_C < 0$ , and therefore  $R_P = R_S + \widetilde{R}_C < 0$ .

In this situation, i.e. multiple losses, the investor should integrate because the value function is convex in the domain of losses.

(c)  $X < S_0 < S_T$ .

This implies that  $R_P = R_S - \alpha \cdot R_C = R_S + \widetilde{R}_C$ ,

with  $R_S > 0$ ,  $R_C > 0$ , so  $\widetilde{R}_C < 0$ , so  $R_P = R_S + \widetilde{R}_C < > 0$ .

If  $R_S > \left| \widetilde{R}_C \right|$ , then  $R_P > 0$ , else  $R_P < 0$ . With a negative portfolio return, the

investor should segregate the gain from the loss if  $R_S$  is very small compared to  $\left| \widetilde{R}_C \right|$ .

This segregation is what Thaler (1985) calls *silver lining*. Otherwise, the investor should integrate both returns.

2.  $X = S_0$ .

(a)  $S_T < X = S_0$ .

This implies that  $R_P = R_S - \alpha \cdot R_C = R_S < 0$ .

(b)  $S_T > X = S_0$ .

$R_P = R_S - \alpha \cdot R_C$ , with  $R_C = R_S > 0$ .

$\left| \widetilde{R}_C \right| = \left| -\alpha \cdot R_C \right| \leq R_S$ , so  $R_P \geq 0$ .

This is a situation of a mixed gain, i.e., the gain is larger than the loss. According to hedonic framing, the investor should integrate.

3.  $X = 1.1 \cdot S_0$ .

(a)  $S_T < S_0 < X$ .

This implies that  $R_P = R_S - \alpha \cdot R_C = R_S < 0$ .

(b)  $S_0 < S_T < X$ .

This implies that  $R_P = R_S - \alpha \cdot R_C = R_S > 0$ .

(c)  $S_0 < X < S_T$ .

$R_P = R_S - \alpha \cdot R_C$ , with  $R_C < R_S$ , so  $\left| \widehat{R}_C \right| < R_S$ , so  $R_P > 0$ .

Again, this is a situation of a mixed gain and the investor should integrate.