A Spreadsheet Application to Evaluate the Performance of Protective Puts

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Abstract

This paper presents a spreadsheet application for performance evaluation of three put strategies adopted in practice. In contrast to the single-period protective put found in finance textbooks, these strategies roll over short maturity options over an extended period. The spreadsheet application provides the instructor with a pedagogical tool to illustrate and explain the measurement of insurance costs, the asymmetric impact of the options on the return distribution of the stock, the impact of exercise price on downside protection and upside reduction, and the dependence of the return on the put strategy on the stock price path.

Introduction

When we first introduce option strategies to students, it is typical to discuss the protective put as a single-period insurance strategy whereby the cost is measured by the premium of the put option and the payoff and profit/loss are computed across a range of hypothetical stock prices on the expiration date of the option (see Bodie, Kane, and Marcus (2009) for example). In reality, Figlewski, Chidambaran, and Kaplan (1993), hereafter FCK, point out that practitioners typically roll over short maturity put options to protect the stock over an extended period. They study three such put strategies, known as the fixed strike strategy, the fixed percentage strategy, and the ratchet strategy, on the basis of the overall cost, extent of downside risk protection, and amount of upside reduction due to the put options. Their work provides a platform for students to advance knowledge beyond the textbook. However, the results are generated by a computer program. Students with limited programming skills may not be able to understand the codes and replicate the analysis to appreciate the execution and results of the strategies.

In this paper, we use Excel ® to illustrate the three strategies interactively so that students can relate the commands to the underlying concepts and see through the evaluation process.[2] We also present a profit/loss diagram to help students visualize the asymmetric impact of the options on the return distribution of the stock, the price to pay for the options on the upside in return for the risk protection received on the downside, and the lack of a one-to-one correspondence between realized stock return and the return on the put strategy.

This paper supports effective learning firstly by engaging students in the learning process that extends their textbook knowledge on the protective put to real life strategies, and secondly by relating the study of the strategies to research and scholarship.[3] It also promotes higher order thinking skills by encouraging students to apply the spreadsheet application and gain hands-on experience with the evaluation process.[4] Furthermore, it motivates student interest by discussing the choice, purpose, and implications of trading strategies that are commonly adopted by the practitioners.[5]

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[2] This paper is intended for courses in the area of funds management at the undergraduate or postgraduate (coursework) level. Students are expected to have knowledge in the Black-Scholes (1973) model and option strategies that are commonly taught in an investments course. The ancillary Excel file and notes are available to the instructor on request.

[3] Chickering and Gamson (1987) suggest that active learning is encouraged when students must read, write, and talk about what they are learning and relate it to their past experiences.

[4] The instructor may illustrate one of the three put strategies and provide a template for students to complete the 2nd and the 3rd. Zimmerman (1998, page 1) suggests that self-regulated learners see “academic learning as something they do for themselves …”. McInnis (2003) reports that students have expressed surprise and excitement when challenged to perform research activities in their assignments and found the work more stimulating and enjoyable than a conventional assignment.

[5] According to Stein (1998, page 1), “Learning is essentially a matter of creating meaning from the real activities of daily living. … and by creating opportunities for learners to live subject matter in the context of real-world challenges, knowledge is acquired and learning transfers from the classroom to the realm of practice.”

The Fixed Strike (FS) Strategy

Definition

To protect the downside risk of a stock for a year, one may overlay the stock with a sequence of twelve one-month European puts with the *same exercise price*, denoted as *X*. FCK call this put strategy the *fixed strike* strategy.

Sample of Stock and Option Prices

We begin the illustration with the use of the following stock price process to simulate a sample of 100 paths of log normally distributed stock prices at monthly intervals over a year:

$$S_{t+1} = S_t \, e^{\mu/12 + \left(\sigma/\sqrt{12}\right) z_t} \qquad (1)$$

Table 1
Random Number Generation and Simulated Stock Price Paths

	A	B	C	D	E	F	G	…	CW
5	z_t when t =	Var 1	2	3	4	5	6		100
6	1	-3.02	0.16	-0.87	0.87	0.21	-0.05		0.01
7	2	-1.05	1.64	-1.07	1.31	0.50	-0.52		-0.55
8	3	-0.16	-0.73	0.20	0.08	0.33	-0.99		0.06
9	4	0.28	1.71	-1.46	1.15	0.40	-0.46		-0.68
10	5	0.11	2.17	-1.61	-1.40	0.06	-0.18		2.44
11	6	-1.77	-0.67	-0.88	-0.68	-1.02	0.31		0.46
12	7	0.60	-0.85	0.51	0.29	0.40	0.11		-0.05
13	8	-1.40	0.87	1.06	-1.15	-0.50	0.18		0.94
14	9	-1.09	0.34	0.13	2.13	-0.09	-0.79		-1.23
15	10	1.12	0.71	-1.76	-0.21	1.52	-1.49		-0.32
16	11	0.89	-1.68	0.89	-0.71	1.27	-0.65		0.15
17	12	1.74	0.27	0.80	-0.19	0.91	0.64		-0.02
…									
27	S_t when t =	Path 1	2	3	4	5	6		100
28	0	100.00	100.00	100.00	100.00	100.00	100.00		100.00
29	1	84.83	101.94	96.08	106.23	102.26	100.71		101.08
30	2	80.65	113.20	91.21	115.73	106.34	98.74		98.89
31	3	80.72	109.61	93.18	117.45	109.47	94.17		100.24
32	4	82.85	122.18	86.52	126.80	113.12	92.62		97.37
33	5	84.20	139.85	79.63	118.16	114.67	92.55		113.21
34	6	76.80	135.91	76.45	114.74	109.19	95.15		117.40
35	7	80.29	130.73	79.51	117.88	112.85	96.72		118.25
36	8	74.82	138.81	85.37	111.40	110.72	98.74		126.09
37	9	70.97	143.01	86.87	127.26	111.25	95.29		118.60
38	10	76.49	150.50	79.26	126.99	122.69	88.30		117.59
39	11	81.35	137.97	84.29	123.14	133.35	85.88		119.84
40	12	90.83	141.56	89.16	122.98	141.95	90.02		120.88

Notes: Table 1 presents a subset of normally distributed random numbers, z_t, and stock prices, S_t. To obtain the entire set of random numbers, first open the random number generation dialogue box in Excel ®: Data → Data Analysis → Random Number Generation; when prompted for the "Number of Variables", enter 100, "Number of Random Numbers", enter 12, "Distribution", select Normal, "Random Seed", enter 1, and finally "Output options", select Output Range at B6. Note that a different seed value will result in a different set of random numbers. To obtain the 100 paths of monthly stock prices for one year, type the initial stock price of $100 in B28, the drift of 0.12 and volatility of 0.20 in G24 and G25 (not shown here), respectively; then in B29, apply these inputs and the corresponding random number, in this case B6, to the stock price process to compute the stock price at the end of the first month for path 1; and finally, copy and paste B28..B29 to B28..CW40.

where S_t and S_{t+1} denote the stock prices at the beginning and the end of the month.[6] Following FCK, the stock has a starting value of \$100 (i.e., $S_0 = 100$), an annual drift (μ) of 12%, and a volatility (σ) of 20%. z_t denotes the normally distributed random number. The first six and the last paths of random numbers and corresponding stock prices are displayed in Table 1.

For each path, the stock prices affect not just the outlay of the new option acquired at the beginning of each month, but also the intrinsic value earned from the expiring option at the end of each month, and ultimately the annual returns on both the stock and the put strategy.

Next we use the Black-Scholes (1973) model to compute the sample of 100 paths of option prices:

$$P_t = X_t e^{-r(T-t)} N(-d_2) - S_t N(-d_1), \text{ where}$$
$$d_1 = \frac{\ln(S_t/X_t) + (r + 0.5\sigma^2)(T-t)}{\sigma\sqrt{(T-t)}}, \; d_2 = d_1 - \sigma\sqrt{(T-t)} \qquad (2)$$

Table 2 presents the inputs supplied to the Black-Scholes model and the option prices that correspond to the seven paths of stock prices reported in Table 1.

Table 2
Simulated Put Option Price Paths

	A	B	C	D	E	F	G	…	CW
47	Risk-free rate (r)						0.05		
48	Time to maturity (T-t)						0.08		
49	Volatility (σ)						0.20		
50	Fixed exercise price (X)						**90**		
51									
52	P_t when t =	Path 1	2	3	4	5	6		100
53	0	0.06	0.06	0.06	0.06	0.06	0.06		0.06
54	1	5.26	0.02	0.30	0.00	0.02	0.04		0.04
55	2	9.04	0.00	1.38	0.00	0.00	0.10		0.10
56	3	8.97	0.00	0.79	0.00	0.00	0.58		0.05
57	4	6.97	0.00	3.95	0.00	0.00	0.93		0.18
58	5	5.78	0.00	10.03	0.00	0.00	0.95		0.00
59	6	12.84	0.00	13.18	0.00	0.00	0.41		0.00
60	7	9.39	0.00	10.15	0.00	0.00	0.23		0.00
61	8	14.81	0.00	4.81	0.00	0.00	0.10		0.00
62	9	18.65	0.00	3.70	0.00	0.00	0.39		0.00
63	10	13.14	0.00	10.40	0.00	0.00	2.78		0.00
64	11	8.38	0.00	5.70	0.00	0.00	4.42		0.00

Notes: Table 2 presents a subset of monthly put option prices. To obtain the 100 paths of put option prices, enter the inputs required by the Black-Scholes (1973) model: r, T-t, σ, and X in G47 to G50 as 0.05, =1/12, 0.20, and 90, respectively; then in B53, apply these fixed values and the corresponding stock price, in this case B28, to Equation (2) to compute the premium of the initial one-month put option (P_0) for path 1; and finally, copy and paste B53 to B53..CW64.

Costs and Benefits of Rolling Over Twelve Put Options

We now open a cash account to isolate the cash flows arising *solely* from the put options to explore the associated costs and benefits, to measure the overall insurance cost, and to explain why the option final payoff and profit/loss are dependent on the stock price path.

At time $t = 0$, we draw P_0 from the account to pay for the 1st put option on the assumption that the option is financed by borrowing. A month later at $t = 1$, the option expires and we will make either ($X_0 - S_1$) if it finishes in the money, or nothing if at or out of the money. Thus we credit the account by max $\{(X_0 - S_1), 0\}$. We also need to deduct from the account, $P_0e^{r(T-t)} – P_0$, to reflect the interest due on the opening debit balance. Finally, we draw P_1 to pay for the 2nd put option to maintain protection for another month. In summary, for the first month, the account opens with -P_0 and closes with:

[6] To learn more about the lognormal distribution, see Kritzman (1992). Although a larger number of paths would lead to a more representative sample, we select 100 for the sake of simplicity and ease of comprehension.

$= -P_0 + \max\{(X_0 - S_1), 0\} - (P_0e^{r(T-t)} - P_0) - P_1$
$= \max\{(X_0 - S_1), 0\} - P_0e^{r(T-t)} - P_1$
$= \max\{(X_0 - S_1), 0\}$ + balance at the beginning of the 1st month $\times\, e^{r(T-t)} - P_1$ (3)

The closing balances for the remaining months are similarly defined except for the end of the year when $t = 12$. Since no new option is needed, the year-end balance is:

$\max\{(X_{11} - S_{12}), 0\}$ + balance at the beginning of the 12th month $\times\, e^{r(T-t)}$ (4)

By capturing all the cash flows associated with the options, each year-end balance reveals the final payoff of the put position for a given stock price path.[7] It also reflects the profit/loss of the put position since the initial payoff (consisting of a long put P_0 and a loan $-P_0$) is 0. The overall annual insurance cost is thus the average of the 100 year-end balances across the 100 stock price paths.

Table 3 shows the monthly cash account balances that correspond to the seven paths of reported stock prices. Whereas a positive year-end balance would help improve the return on the stock and demonstrate the benefit of using put options to protect the downside risk of the stock, a negative balance would imply that the stock's upside could be reduced by the associated cost of insurance.[8]

Table 3
Monthly Cash Account Balances arising from the Put Options

	A	B	C	D	E	F	G	…	CW
76	Cash a/c when t =	Path 1	2	3	4	5	6		100
77	0	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06		-0.06
78	1	-0.15	-0.09	-0.36	-0.06	-0.08	-0.11		-0.10
79	2	0.16	-0.09	-1.74	-0.06	-0.09	-0.21		-0.20
80	3	0.47	-0.09	-2.54	-0.06	-0.09	-0.79		-0.25
81	4	0.65	-0.09	-3.02	-0.06	-0.09	-1.72		-0.44
82	5	0.67	-0.09	-2.69	-0.06	-0.09	-2.68		-0.44
83	6	1.04	-0.09	-2.33	-0.07	-0.09	-3.11		-0.44
84	7	1.36	-0.09	-2.00	-0.07	-0.09	-3.35		-0.44
85	8	1.74	-0.09	-2.20	-0.07	-0.09	-3.47		-0.44
86	9	2.12	-0.09	-2.78	-0.07	-0.09	-3.88		-0.45
87	10	2.50	-0.09	-2.44	-0.07	-0.09	-4.98		-0.45
88	11	2.79	-0.09	-2.45	-0.07	-0.09	-5.30		-0.45
89	12	2.80	-0.09	-1.62	-0.07	-0.09	-5.32		-0.45

Notes: Table 3 presents a subset of monthly balances of a cash account created to capture the cash flows resulting from rolling over twelve one-month put options. To obtain the 100 paths of monthly balances, set the opening balance for path 1 in B77 equal to –B53 or $-P_0$, the money borrowed to purchase the initial one-month put option; apply Equation (3) to compute the balance at the end of the first month in B78; copy and paste B77..B78 to B77..CW88 to obtain the month-end balances in subsequent months up to the end of the eleventh month; apply Equation (4) to compute the balance at the end of the twelfth month in B89; and finally, copy and paste B89 across to B89..CW89.

To further illustrate that the final payoff or profit/loss is dependent on the stock price path, we sort the stock price paths by the year-end balance. For this data set, the two stock price paths that result in the largest and smallest year-end balances are plotted in Diagram 1.

The diagram shows that when the stock suffers from a persistent downtrend in path 95, the majority of the put options finishes in the money and returns the largest profit to offset the loss incurred by the stock, thus *protecting the downside*. When the stock moves sideways and stays mostly above X in path 83, the majority of the put options finishes out of the money and returns the largest loss to *reduce the upside* of the stock.

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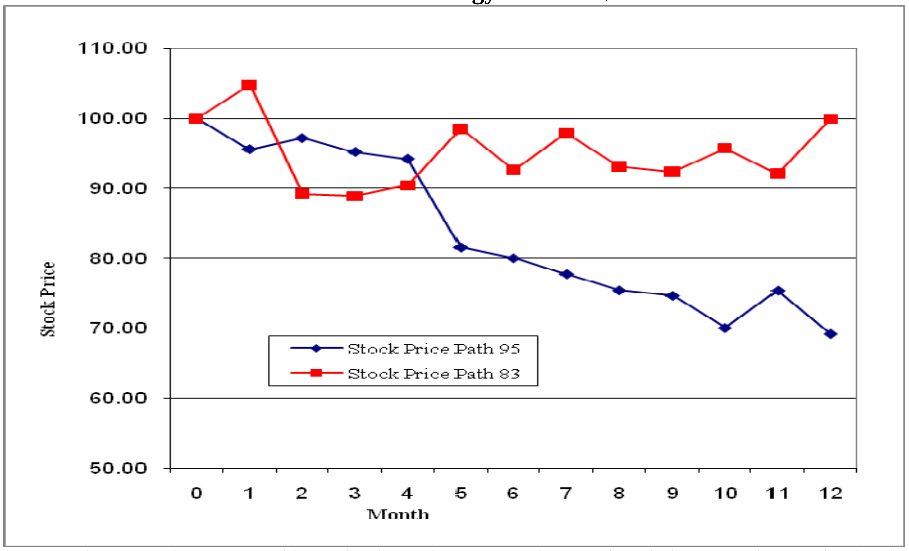
[7] It is clear from Equations (3) and (4) that the year-end balance is dependent on the stock price path ($S_1, S_2, \ldots, S_{12}$) rather than the single year-end stock price (S_{12}). The two equations also show that the stock price observed in each month affects not only the intrinsic value of the expiring option, but also the premium paid for the new put, both of which in turn determine the cash account balance at the beginning of each month and the consequent interest earned or charged at the end of the month.

[8] A positive (negative) year-end balance occurs when during the year the total intrinsic value received from the puts finishing in the money and the total interest earned exceed (fall short of) the total premium paid and the total interest charged.

Diagram 1
Stock Price Paths that Leads to the Most and Least Returns on the Fixed Strike Strategy with X = $90



Notes: Diagram 1 plots two monthly stock price paths over a twelve month period. Among the 100 simulated paths, paths 95 and 83 result in the largest and smallest year-end cash account balances respectively. To identify and plot the paths, transpose the 13 rows of monthly balances in A76..CW89 (including the labels for the columns and rows as displayed in Table 3) to 13 columns of monthly balances in A234..N334; copy and paste only the values of the transposed data to the same location to remove the existing links; sort the table by the last column that shows the year-end balance in a descending order; identify the stock price paths that correspond to the largest and smallest year-end balances in the first and last rows of sorted data; and finally, use the chart wizard to plot the two stock price paths obtained from Table 1.

Annual Returns on the Stock and the Put Strategy

For each path, an investor who invests in the stock only would earn an annual discrete return of:

$$S_{12}/S_0 - 1 \tag{5}$$

Table 4
Discrete Returns on the Stock and the Fixed Strike (FS) Strategy

	A	B	C	D	E	F	G	…	CW
97	Return	Path 1	2	3	4	5	6		100
98	Long Stock	-9.2%	41.6%	-10.8%	23.0%	41.9%	-10.0%		20.9%
99	FS: X=90	-6.4%	41.5%	-12.5%	22.9%	41.9%	-15.3%		20.4%
100	FS: X=95	-1.2%	40.7%	-6.0%	22.4%	41.1%	-15.8%		17.6%
101	FS: X=100	2.5%	37.8%	1.0%	20.3%	37.6%	-7.4%		12.3%
102	FS: X=105	4.3%	34.1%	4.1%	14.8%	30.3%	1.7%		13.9%
103	FS: X=110	5.0%	28.1%	4.9%	7.8%	19.9%	4.5%		9.4%

Notes: Table 4 presents a subset of annual discrete returns on the stock only strategy and the fixed strike strategy with X in the range of $90 to $110. To obtain the 100 paths of returns on the stock, apply Equation (5) to B93 (which is not shown here); then copy and paste B93 across to B93..CW93; and finally, copy and paste only the values in B93..CW93 to B98..CW98. To obtain the 100 paths of returns on the put strategy for X = 90, apply Equation (6) to B94 (which is not shown here); then copy and paste B94 across to B94..CW94; and finally, copy and paste only the values in B94..CW94 to B99..CW99. To obtain the 100 paths of returns on the put strategy for the other exercise prices, raise the value of X in G50 in $5 increments to obtain another set of returns in B94..CW94, the values of which are copied and pasted to another row below the last X (i.e., from B100..CW100 to B103..CW103, one row at a time), until X reaches $110.

Had the investor overlaid the stock with the put options, the investor would have paid S_0 to establish the position that contains the stock, the first put option, and the loan (S_0+P_0–P_0). One year later, the investor would be entitled or liable to the cumulated cash flow of the options and the year-end value of the stock. Thus the annual discrete return on the put strategy is:

$$(S_{12} + \text{year-end cash account balance})/S_0 - 1 \tag{6}$$

Table 4 shows the annual returns on the stock and the fixed strike strategy that correspond to the seven stock price paths reported in Table 1. Besides computing the returns on the put strategy for X = 90, we progressively raise the value of X in G50 from \$90 to \$110, \$5 at a time, to obtain more return data to study the impact of exercise price on the performance of the put strategy.

Results and Performance Evaluation

We now have the inputs to produce the performance table as in FCK which includes the mean and standard deviation of returns, the percentile returns, and the percentage of options finishing in-the-money. These measures, which are reported in Table 5, are used to evaluate the performance of the protective put: the expected insurance -cost to protect the underlying stock, the extent of downside risk protection offered by the options, and the amount of upside reduction taken away by the options.

Table 5
Performance Table for the Fixed Strike Strategy

	A	B	C	D	E	F	G	H	I	J
212						Fixed Strike Strategy				
213	**Fixed Strike Strategy**				Stock	with a Fixed Exercise Price of				
214					Only	90	95	100	105	110
215	Mean Return				15.0%	14.1%	13.6%	12.8%	12.0%	11.0%
216	Standard Deviation of Returns				25.5%	25.3%	24.4%	22.5%	19.8%	17.2%
217										
218	Probability Distribution									
219	5th percentile – disaster				-21.0%	-15.1%	-12.1%	-11.4%	-8.1%	-5.8%
220	25th percentile - bad year				-5.5%	-9.2%	-6.1%	-4.7%	-1.1%	2.6%
221	75th percentile - good year				30.6%	30.5%	28.0%	25.0%	21.3%	16.0%
222	95th percentile - great year				51.54%	51.47%	51.0%	49.0%	43.9%	39.1%
223										
224	% options in-the-money					13.3%	23.6%	37.3%	52.1%	63.8%

Notes: Table 5 summarizes the outcomes of the stock only strategy and the fixed strike strategy. To obtain the statistical measures, transpose the six rows of returns in B98..CW103 and position the output in a blank area (such as B110..G209 which is not shown in the table); then for the stock only strategy, apply the built-in Excel functions to the sample of 100 stock returns in B110..B209 to compute the mean and standard deviation in E215..E216, and the 5th, 25th, 75th, and 95th percentiles in E219..E222; and finally, copy and paste E215..E222 across to F215..J222 to obtain the same set of statistics for each of the five exercise price levels. To obtain the percentage of options finishing in-the-money for each exercise price level, apply the built-in Excel function to count the number of times the month end stock prices in B29..CW40 falling below the fixed exercise price and divide the number by 1200 (100 paths of 12 monthly stock prices).

The year-end balances in Table 3 represent the sample distribution of annual insurance costs. Since the put strategy costs S_0 to establish, the expected annual percentage insurance cost is:

$$\text{average year-end cash account balance}/S_0 \tag{7}$$

But Equation (7) is also the difference between the mean values of Equations (6) and (5). Thus we can measure the annual insurance cost by deducting the mean annual return on the stock from that on the protective put.[9] Table 5 shows that the expected annual insurance cost is -0.9% or 90 cents (14.1%-15.0%) for rolling over 12 put options, each with X = \$90; rises with option exercise price (from -0.9% for X = \$90 to -4.0% for X = \$110); and is less than 12 times the cost of the first option for $X \geq$ \$95.

FCK point out that the put strategy is designed to limit risk on the downside and users have to pay for the protection by giving up some of the upside. This asymmetric impact means that it is not appropriate to use standard deviation (a two-sided risk measure) to evaluate the protectiveness of the put strategy and the sacrifice on the upside (each of which is a one-sided criterion). They further emphasize that the lack of a one-to-one correspondence between realized stock return (which depends

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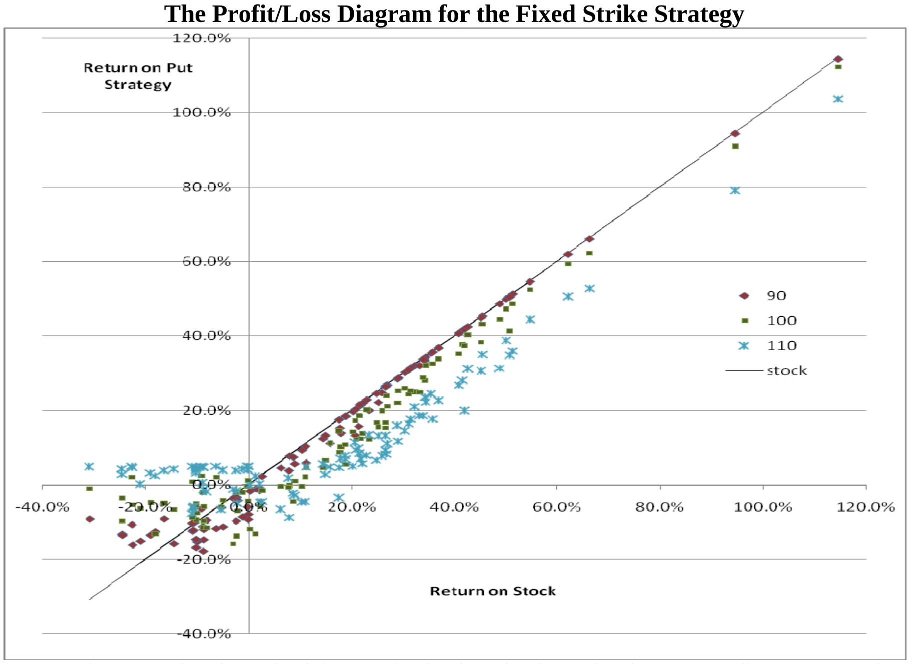
[9] FCK refer to the performance table to compute the insurance cost by deducting the mean annual return on the stock from that on the protective put. We add the rationale behind and help readers understand the computation by linking the difference in returns to the average year-end cash flows of the options bought to protect the stock.

only on the final stock price) and the return on the put strategy (which depends on the stock price path) means that it may not be possible to identify a certain stock return below which the put strategy dominates the stock only strategy. Thus, they suggest examining the percentile returns to appreciate the asymmetric impact and to compare the two strategies whereby the 5th and 25th percentiles are used to evaluate the protectiveness of the put strategy in a disaster and a bad year, respectively; and the 75th and 95th percentiles to evaluate the upside tradeoff in a good and a great year, respectively.

For this sample, the percentile returns in Table 5 suggest that there is a 5% chance of losing more than 21.0% on the stock. The put strategy is unable to avoid large losses. Despite fixing *X* at \$90 or 10% below the initial stock value, a loss of at least 15.1% is expected 5% of the time. Nevertheless, for the same percentile, a better downside protection is achieved by choosing a higher exercise price which corresponds to a larger percentile return.

On the upper tail of the distribution, the stock offers a return of at least 51.54% in a great year. The \$90 put strategy takes little away from the upside with a 95th percentile return of 51.47%. However, investors who choose a higher *X* for better downside protection must forgo more return on the upside.

Diagram 2
The Profit/Loss Diagram for the Fixed Strike Strategy



Notes: Diagram 2 plots for each of the 100 simulated stock price paths, the corresponding returns on the stock only strategy (joined by the 45° line) and on the fixed strike strategy with exercise prices in the range of \$90 to \$110 at \$10 intervals. We use the X Y scatter plot (with markers only) in Excel ® to produce the graph. The return co-ordinates for *X* = 95 and *X* = 105 are not included to avoid overcrowding of data points.

We present in Diagram 2 a profit/loss diagram for the fixed strike strategy to supplement the percentile return analysis. The 45° line joins the return coordinates of the stock only strategy. It is the benchmark for comparison to the put strategy. For each exercise price level, the extent of downside protection (or upside reduction) for a particular stock price path is reflected by the distance of above (or below) the 45° line. The diagram shows that for each and every exercise price the multiple put options acquired during the year change the stock return distribution the same way as a single put option. As the investor suffers from unfavorable (enjoys favorable) stock price movements at the lower (upper) tail of the distribution, the put strategy could hedge the loss (lower the gain). Besides, while the choice of a higher exercise price tends to protect the downside better, it also tends to take away more return from the stock on the upside. Furthermore, the stock price path that experiences the larger fall (rise) does not always correspond to a larger downside protection (upside reduction) for the protective put, reinforcing FCK's emphasis on the lack of one-to-one correspondence between realized stock return and the return on the put strategy.

The Fixed Percentage (FP) and Ratchet (RAT) Strategies

At the end of each month, instead of replacing the expired put option with a new option that has the same exercise price, the FP strategy sets the exercise price of each and every option to a predetermined percentage value (ρ) of the concurrent stock price. Thus

$$X_t = \rho S_t \tag{8}$$

for $t = 0, 1, 2, \ldots, 11$; and ρ ranges from 0.90 , 0.95, 1.00, 1.05 to 1.10 in this study.

On the other hand, the RAT strategy sets the exercise price to the larger of that of the last option and a predetermined percentage value (ρ) of the concurrent stock price. Thus

$$X_0 = \rho S_0, \text{ and } X_t = \max(X_{t-1}, \rho S_t) \text{ for } t = 1, 2, \ldots, 11. \tag{9}$$

Table 6
Performance Tables for the Fixed Percentage and Ratchet Strategies

	A B C D	E	F	G	H	I	J
204				Fixed Percentage Strategy			
205	**Fixed Percentage Strategy**	Stock		with a predetermined ρ of			
206		Only	0.90	0.95	1.00	1.05	1.10
207	Mean Return	15.0%	14.9%	14.1%	11.2%	7.2%	5.8%
208	Standard Deviation of Returns	25.5%	24.9%	22.5%	16.4%	8.8%	3.9%
209							
210	Probability Distribution						
211	5th percentile – disaster	-21.0%	-18.9%	-13.9%	-12.4%	-3.5%	3.1%
212	25th percentile - bad year	-5.5%	-4.5%	-4.0%	-0.8%	1.2%	3.3%
213	75th percentile - good year	30.6%	29.7%	25.9%	20.6%	11.0%	6.5%
214	95th percentile - great year	51.5%	50.6%	49.5%	34.3%	21.1%	12.7%
215							
216	% options in-the-money		2.6%	15.0%	41.8%	75.4%	93.8%

	A B C D	E	F	G	H	I	J
221				Ratchet Strategy			
222	**Ratchet Strategy**	Stock		with a predetermined ρ of			
223		Only	0.90	0.95	1.00	1.05	1.10
224	Mean Return	15.0%	13.6%	12.1%	9.1%	6.2%	5.7%
225	Standard Deviation of Returns	25.5%	23.9%	20.7%	14.7%	7.9%	3.4%
226							
227	Probability Distribution						
228	5th percentile – disaster	-21.0%	-14.8%	-10.2%	-5.7%	-0.3%	3.5%
229	25th percentile - bad year	-5.5%	-6.2%	-3.3%	-0.1%	1.8%	4.0%
230	75th percentile - good year	30.6%	27.7%	21.1%	14.5%	8.5%	5.0%
231	95th percentile - great year	51.5%	50.0%	49.4%	31.6%	21.1%	13.2%
232							
233	% options in-the-money		22.1%	40.1%	63.6%	87.1%	96.8%

Notes: Table 6 summarizes the outcomes of the fixed percentage and ratchet strategies. For each strategy we begin with the same 100 stock price paths as the fixed strike strategy. A new set of put premiums is then computed using the same inputs as the fixed strike strategy except for the exercise price where Equation (8) is now used for the fixed percentage strategy and Equation (9) for the ratchet strategy. Once the put premiums are computed for each and every ρ, a new set of cash account balances and discrete returns on the put strategy will be generated automatically (from the existing links that we carry over from the fixed strike strategy) for us to complete the performance table.

We add Equations (8) and (9) to emphasize that it is the exercise price that distinguishes the three put strategies and to provide the algorithm to compute alternative exercise price paths. To implement the FP strategy using Excel, we make two modifications to the spreadsheet application designed for the FS strategy. First, replace the previously fixed dollar amount of X (as shown in G50 of Table 2) by the percentage value as specified by ρ. Second, replace the previously fixed exercise price supplied to the Black-Scholes equation by the product of ρ and the corresponding stock price as suggested by Equation (8). Similarly, to implement the RAT strategy, we begin with the same spreadsheet application designed for the FP strategy. The only change made is to replace the exercise price supplied to the Black-Scholes equation by the larger of the last exercise price and the product of ρ and the corresponding stock price as suggested by Equation (9).

For this sample, the performance tables for the FP and RAT strategies are presented in Table 6. The results are consistent with those reported in FCK. For each strategy, choosing a higher X would provide a better downside protection at the expense of a larger insurance cost and return forgone on the upside. For each exercise price level, the RAT strategy offers the best protection among the three.

Conclusion

In this paper, we present a spreadsheet application to conduct performance evaluation of three protective put strategies that involve rolling over short maturity options for one year. These strategies are distinguished by the algorithm used to compute the exercise price of the options purchased during the year. The spreadsheet application is intended for classroom demonstration and discussion. It provides the instructor a pedagogical tool to illustrate interactively how the pattern of stock price movements during the year can affect the cumulated profit/loss of the put options at the end of year and ultimately the return on each roll-over protective put strategy. Through the interactive computation of cash flows that arise solely from the put options purchased during the year, the instructor can also highlight the costs and benefits associated with the put options and illustrate the computation of the overall insurance cost. The instructor can further enhance the interpretation of results with the use of a profit/loss diagram to emphasize the asymmetric impact of the put options on the return distribution of the stock, and the tradeoff between risk protection on the downside and return sacrifice on the upside.

After demonstrating the spreadsheet application, the instructor may provide students with a template to complete on their own and gain hands-on experience with the process of performance evaluation. The instructor may also give each student a different seed to base the study on a different set of stock prices and hence a different set of outcomes. Furthermore, the instructor may ask students to extend the application and explore issues that are examined in FCK but not discussed here. For example, students may investigate the impact of roll-over frequency on the performance of the put strategies by changing the option maturity and the number of options rolled over during the year.

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