Portfolio Replacement Strategies

SONIA AHLUWALIA KHANNA and ANWEI LI and AARON ROBINSON

Introduction

A recent Barron's article suggests a portfolio replacement strategy in anticipation of a rise in stock market volatility. Specifically, the author suggests replacing a position in S&P 500 index shares with call options in order to reduce the risk to principle, take advantage of an expected volatility spike, and maintain long exposure to the underlying. The purpose of this paper is to examine the historical effectiveness of the proposed strategy and test an alternate portfolio consisting of a zero beta straddle. A zero beta straddle would be the appropriate pure strategy to handle a volatility spike. A call option portfolio would only benefit from a volatility spike with an upward bias in the underlying. We also examine the Sharpe ratios of the actual portfolios, as returns are an incomplete comparative measure as options have different risk-return characteristics than stocks, driven by the leverage effect and curvature of payoffs.

The paper focuses on testing the returns of three portfolios. The first is a control case consisting of shares in the S&P 500 index. The second is the position recommended in the Barron's article, consisting of calls on the same number of S&P 500 shares as held in the first portfolio and enough risk free bonds to make an equivalent dollar exposure. The third portfolio is our recommended position for an investor expecting a volatility spike, consisting of a straddle and risk free bonds.

We further investigate the Coval and Shumway (2001) finding that that observed that weekly call option returns were roughly two percent too low relative to Black-Scholes predictions. The deficiency was interpreted as compensation to option writers for anticipated stochastic volatility, a feature not captured by the Black-Scholes model. Lower than expected call option returns could reduce the call option portfolio's sensitivity to positive share price movements. The effect could be particularly evident in a market where market makers anticipate volatility spikes.

Theoretical Expectations

We expect the portfolio of call options and risk free bonds to have a lower risk-return profile than the share portfolio despite the higher return and volatility expectations of the actual options. The baseline assumption in pricing options is that share prices follow the process $dS/S = (\alpha-\delta)dt + \sigma dZ$. The Black-Scholes asset pricing framework specifies that call options always have betas that are larger than the assets upon which they are written. We therefore expect call options on market indices to have long run returns greater than those of the underlying indices. The call options have a standard deviation equal to the standard deviation of the underlying times their elasticity, meaning the option standard deviation must always exceed that of the underlying. This expectation was confirmed by Coval and Shumway (2001) in their empirical study. However, the risk free bonds make up the majority of the replacement portfolio are insensitive to changes in share prices and result in an overall exposure with lower expected returns and volatility than the share only portfolio. Thus, the replacement suggested replacement strategy would be expected to protect principle while providing some exposure to share price movements.

The purest expression of a strategy intended to profit from a volatility spike is a market neutral straddle. The Black-Scholes asset pricing framework predicts that this zero beta portfolio and must earn the risk free rate if volatility is constant because it does not have exposure to market risk. Although straddle returns are not sensitive to market direction, they are sensitive to market volatility. Straddles have positive returns when market volatility is higher than expected and lower returns when market volatility is lower than expected. Straddles have high sensitivity to market volatility and therefore allow investors to hedge against or speculate on volatility. In contrast with Black-Scholes predictions, Coval and Shumway (2001) found in their empirical study that market neutral straddles on the S&P 500 index receive average weekly returns of minus three percent per week. Their conclusion is that stochastic volatility is priced into the options, an assumption absent from the Black-Scholes model. The interpretation is that market makers, the straddle writers in this case, require a three percent return per week in order to entice them into taking the risk that volatility will rise. This suggests that holders of the straddle in portfolio three will have to pay three percent per week to gain exposure to the expected volatility spike. We expect our analysis to echo the Coval and Shumway (2001) results but show positive returns for periods where a substantial spike in volatility occurs. An important question is whether gains on straddle portfolios resulting from volatility spikes make up for interim losses, and the mean length of the breakeven holding period.

Data and Method

We turn to data to test the above expectations, using the OptionMetrics database available through Wharton Research Data Services. We examine the daily returns of the S&P index, options, VIX and four portfolio strategies over a five year period, from April 2001 through April 2006. Our method of calculating portfolio returns is as follows. We identified at the money European options with six months to expiration and collected data for the ensuing three months. Thus, we observed options with roughly 180 to 90 days to expiration. We calculate daily returns based on the midpoint of the closing bid-ask spread. All of our calculations rely on logarithmic returns, which are widely accepted in stock pricing literature. Coval and Shumway (2001) use raw net returns to handle the common result of a -1 return for options held to maturity, but our data does not require this adjustment. Thus, our calculation method is consistent with the Sheikh and Ronn (1994) study of option returns.

Evidence

Our data sample focuses on S&P 500 index options over a five year period from January 2001 through December 2006. The index posted average daily returns of 0.02% percent or 6.3% percent on an annualized basis. S&P 500 returns over this period do not contain the abnormally high returns seen in the late 1990s, but do include the market crash and recovery surrounding September 11, 2001. This inclusion adds interest to our result.

In our analysis, we examine returns and Sharpe ratios for four portfolio strategies:

- Portfolio Strategy 1 (P1): Hold – only hold the Index in the portfolio
- Portfolio Strategy 2 (P2): Replacement– replace each unit of the Index with one Call option and buy T-bills with the remainder (the strategy recommended in the Barron's article)
- Portfolio Strategy 3 (P3): Straddle – replace each unit of the Index with one Call, one Put and T-bills for the remainder (pure volatility strategy)

- Portfolio Strategy 4 (P4): Covered Call – hold the Index, and short one Call for each unit of the index being held; hold T-bills with the proceeds from shorting the call

Table 1 shows the cumulative period returns for the index, call, put, and portfolio returns over the sample period. We see that the call option returns are more exaggerated than those of the underlying index and put option returns are generally opposite. The put returns are mostly negative, which is expected due to the upward trend in the S&P 500 over the last five years, and supports the Coval and Shumway (2001) result. P4 largely outperforms the other portfolios, indicating that it is more profitable to own the index and sell a call than hold a call or simply own the index. This implies that the value gained from selling a call is greater than the increase in call price when owning the call. However, this analysis does not hold the call until expiration; therefore it does not take into account the value that will be gained or lost when the call options are exercised. In the majority of cases, P2 and P3 are the worst performing portfolios, implying that the replacement strategy (P2) is inferior to plainly holding the index (P1) over the long run. P3, a pure volatility play, is the worst performing overall, but outperforms the other portfolios when volatility spikes, such as in the time period of September 11, 2001. This result is closely correlated to the returns on the VIX, which is demonstrated by positive betas (Table 3).

Sharpe ratios for the portfolios are in Table 2. We observe that the covered call (P4) still has the highest Sharpe ratios compared to the other portfolios, which also supports its superior performance over this period. This means it is profitable on a risk adjusted basis to sell risk and return in the tails of the share price distribution. Considering the moderate returns and generally decreasing volatility during the period, it is not surprising that such a strategy outperforms portfolios exposed to the only to the underlying or volatility. It would be interesting to examine the performance of a covered call strategy in a period of abnormally higher returns, such as seen in the late 1990s.

Table 3 shows the regression beta calculated between each of the portfolio returns against the returns on the VIX. The betas on the Index and the Call are generally negative, while the put and straddle have positive correlations. This would suggest that the volatility is trending in a negative direction, i.e. increases in volatility are due to bad news more often than good news. The covered call (P4) is a hedged position, so the betas are largely of smaller magnitude than holding the index alone (P1).

Conclusion

From our empirical results, we concluded that the Barron's asset replacement strategy generally had worse performance than holding the asset, however did perform better in times of high volatility. However, the pure volatility strategy (straddle) performed even better in times when there was a volatility spike. On average, the covered call performed the best because of the upward trend in the market, generally low volatility in the 5 year period, and because it is a hedged position.

References

Coval, J. D. and Shumway, T., 2001, Expected Option Returns, *Journal of Finance*, 56(3), 983–1009.

Sheikh, Aamir, and Ehud I. Ronn, 1994, A characterization of the daily and intraday behavior of returns on options, *Journal of Finance* 49, 557-579.

Sears, Steven M., The Striking Price, Hedging Their Worries Away, *Barron's*, February 12, 2007.

Table 1: Period Returns

Period			Option		Period Return								
Start	End	# Days	Exdate	Strike	Avg. Risk-free	VIX	SPX	Call	Put	P1	P2	P3	P4
4/10/2001	6/22/2001	73	9/22/2001	1,175	3.7%	(38.6%)	4.8%	9.3%	(100.7%)	4.8%	1.1%	(2.7%)	6.2%
6/25/2001	9/21/2001	88	12/22/2001	1,225	3.3%	72.5%	(23.3%)	(346.1%)	140.1%	(23.3%)	(5.1%)	10.1%	(14.5%)
9/17/2001	12/14/2001	88	3/16/2002	1,050	2.0%	(52.8%)	7.8%	25.0%	(125.2%)	7.8%	2.4%	(3.3%)	8.0%
12/24/2001	3/22/2002	88	6/22/2002	1,150	1.7%	(24.1%)	0.4%	(54.7%)	(53.5%)	0.4%	(2.2%)	(4.7%)	4.6%
3/25/2002	6/21/2002	88	9/21/2002	1,135	1.7%	38.8%	(13.5%)	(269.3%)	100.6%	(13.5%)	(4.6%)	3.6%	(6.4%)
6/24/2002	9/20/2002	88	12/21/2002	995	1.7%	36.8%	(16.1%)	(231.2%)	97.6%	(16.1%)	(5.7%)	4.3%	(7.3%)
9/23/2002	12/20/2002	88	3/22/2003	850	1.4%	(39.6%)	7.2%	20.2%	(95.0%)	7.2%	1.9%	(4.0%)	7.8%
12/23/2002	3/21/2003	88	6/21/2003	900	1.2%	9.0%	(0.2%)	(41.6%)	(31.6%)	(0.2%)	(2.2%)	(4.2%)	4.3%
3/24/2003	6/20/2003	88	9/20/2003	875	1.1%	(46.2%)	14.2%	(187.2%)	64.0%	14.2%	(5.0%)	1.8%	20.1%
6/23/2003	9/19/2003	88	12/20/2003	995	0.9%	(16.0%)	5.4%	35.4%	(95.3%)	5.4%	2.0%	(1.7%)	5.0%
9/22/2003	12/19/2003	88	3/20/2004	1,025	0.9%	(18.0%)	6.2%	37.8%	(135.1%)	6.2%	2.4%	(1.7%)	5.6%
12/22/2003	3/19/2004	88	6/19/2004	1,100	0.9%	12.3%	1.5%	2.6%	(34.6%)	1.5%	0.2%	(1.1%)	2.6%
3/22/2004	6/18/2004	88	9/18/2004	1,100	1.0%	(36.4%)	3.6%	(87.4%)	(101.6%)	3.6%	(2.7%)	(6.4%)	7.7%
6/23/2004	9/17/2004	86	12/18/2004	1,135	1.4%	(4.1%)	(0.9%)	(25.2%)	(25.2%)	(0.9%)	(0.6%)	(1.5%)	1.2%
9/20/2004	12/17/2004	88	3/19/2005	1,125	2.0%	(12.5%)	7.0%	(161.6%)	(161.6%)	7.0%	(3.1%)	(6.7%)	11.3%
12/20/2004	3/18/2005	88	6/18/2005	1,200	2.5%	11.6%	(0.4%)	(25.1%)	(25.1%)	(0.4%)	(0.4%)	(1.2%)	1.6%
3/21/2005	6/17/2005	88	9/17/2005	1,175	2.9%	(17.0%)	2.8%	44.1%	(103.6%)	2.8%	2.2%	0.2%	2.0%
6/20/2005	9/16/2005	88	12/17/2005	1,225	3.3%	(2.2%)	1.8%	(6.3%)	(59.7%)	1.8%	0.3%	(1.2%)	3.1%
9/19/2005	12/16/2005	88	3/18/2006	1,225	3.8%	(12.8%)	2.9%	9.4%	(101.5%)	2.9%	1.1%	(0.9%)	3.9%
12/19/2005	3/17/2006	88	6/17/2006	1,250	4.3%	6.3%	3.7%	21.7%	(121.2%)	3.7%	1.9%	(0.1%)	4.1%
Average					***2.1%***	***(6.7%)***	***0.7%***	***(61.5%)***	***(48.4%)***	***0.7%***	***(0.8%)***	***(1.1%)***	***3.5%***
Annualized					***8.8%***	***(27.9%)***	***3.1%***	***(257.6%)***	***(202.8%)***	***3.1%***	***(3.4%)***	***(4.5%)***	***14.8%***

Portfolio Strategy 1 (P1): Hold – only hold the Index in the portfolio
Portfolio Strategy 2 (P2): Replacement– replace each unit of the Index with one Call option and T-bills (remainder)
Portfolio Strategy 3 (P3): Straddle – replace each unit of the Index with one Call, one Put and T-bills (remainder)
Portfolio Strategy 4 (P4): Covered Call – hold the Index, and for each unit of the index, short one Call and buy T-bills with proceeds

Table 2: Sharpe Ratios

Period			Option		Sharpe Ratio							
Start	End	# Days	Exdate	Strike	VIX	SPX	Call	Put	P1	P2	P3	P4
4/10/2001	6/22/2001	73	9/22/2001	1,175	(1.0)	0.4	0.1	(0.9)	0.4	0.1	(0.8)	1.3
6/25/2001	9/21/2001	88	12/22/2001	1,225	1.2	(2.0)	(2.2)	1.3	(2.0)	(1.4)	1.4	(1.7)
9/17/2001	12/14/2001	88	3/16/2002	1,050	(1.2)	0.6	0.3	(1.1)	0.6	0.3	(0.8)	1.2
12/24/2001	3/22/2002	88	6/22/2002	1,150	(0.5)	(0.0)	(0.4)	(0.5)	(0.0)	(0.6)	(1.8)	0.6
3/25/2002	6/21/2002	88	9/21/2002	1,135	0.7	(1.2)	(1.7)	0.9	(1.2)	(1.3)	0.7	(0.9)
6/24/2002	9/20/2002	88	12/21/2002	995	0.5	(0.8)	(1.1)	0.8	(0.8)	(1.1)	0.4	(0.5)
9/23/2002	12/20/2002	88	3/22/2003	850	(0.8)	0.4	0.2	(0.7)	0.4	0.2	(0.9)	0.9
12/23/2002	3/21/2003	88	6/21/2003	900	0.2	(0.0)	(0.3)	(0.4)	(0.0)	(0.5)	(1.0)	0.4
3/24/2003	6/20/2003	88	9/20/2003	875	(1.4)	1.4	(1.7)	0.8	1.4	(1.3)	0.4	1.7
6/23/2003	9/19/2003	88	12/20/2003	995	(0.5)	0.7	0.4	(1.1)	0.7	0.4	(1.3)	1.1
9/22/2003	12/19/2003	88	3/20/2004	1,025	(4.9)	6.9	4.9	(15.5)	6.9	3.8	(12.8)	9.6
12/22/2003	3/19/2004	88	6/19/2004	1,100	0.2	0.2	0.0	(0.3)	0.2	0.0	(0.7)	0.6
3/22/2004	6/18/2004	88	9/18/2004	1,100	(7.2)	3.4	(6.2)	(10.0)	3.4	(6.3)	(9.0)	6.1
6/23/2004	9/17/2004	86	12/18/2004	1,135	(1.1)	(3.5)	(3.2)	(3.2)	(3.5)	(4.8)	(3.4)	(0.3)
9/20/2004	12/17/2004	88	3/19/2005	1,125	(3.6)	7.3	(16.1)	(16.1)	7.3	(16.5)	(13.9)	9.4
12/20/2004	3/18/2005	88	6/18/2005	1,200	2.1	(4.5)	(2.5)	(2.5)	(4.5)	(9.4)	(6.0)	(0.9)
3/21/2005	6/17/2005	88	9/17/2005	1,175	(3.1)	(0.1)	4.0	(9.2)	(0.1)	(2.0)	(7.8)	(1.4)
6/20/2005	9/16/2005	88	12/17/2005	1,225	(1.2)	(2.6)	(1.1)	(6.2)	(2.6)	(10.3)	(51.5)	(0.6)
9/19/2005	12/16/2005	88	3/18/2006	1,225	(3.0)	(1.3)	0.6	(9.9)	(1.3)	(8.4)	(25.4)	0.3
12/19/2005	3/17/2006	88	6/17/2006	1,250	0.4	(1.0)	2.3	(10.9)	(1.0)	(6.6)	(24.9)	(0.8)

Portfolio Strategy 1 (P1): Hold – only hold the Index in the portfolio
Portfolio Strategy 2 (P2): Replacement– replace each unit of the Index with one Call option and T-bills (remainder)
Portfolio Strategy 3 (P3): Straddle – replace each unit of the Index with one Call, one Put and T-bills (remainder)
Portfolio Strategy 4 (P4): Covered Call – hold the Index, and for each unit of the index, short one Call and buy T-bills with proceeds

Table 3: Regression Betas with respect to returns on the VIX

Period			Option		Beta-VIX						
Start	**End**	**# Days**	**Exdate**	**Strike**	**SPX**	**Call**	**Put**	**P1**	**P2**	**P3**	**P4**
4/10/2001	6/22/2001	73	9/22/2001	1,175	(0.19)	(1.51)	2.33	(0.19)	(0.14)	(0.08)	(0.06)
6/25/2001	9/21/2001	88	12/22/2001	1,225	(0.17)	(1.96)	1.55	(0.17)	(0.05)	0.08	(0.11)
9/17/2001	12/14/2001	88	3/16/2002	1,050	(0.20)	(1.38)	2.02	(0.20)	(0.11)	(0.02)	(0.09)
12/24/2001	3/22/2002	88	6/22/2002	1,150	(0.17)	(2.06)	1.70	(0.17)	(0.07)	0.04	(0.10)
3/25/2002	6/21/2002	88	9/21/2002	1,135	(0.19)	(2.45)	1.84	(0.19)	(0.05)	0.08	(0.13)
6/24/2002	9/20/2002	88	12/21/2002	995	(0.28)	(2.31)	1.62	(0.28)	(0.05)	0.14	(0.21)
9/23/2002	12/20/2002	88	3/22/2003	850	(0.25)	(1.67)	1.96	(0.25)	(0.13)	(0.01)	(0.12)
12/23/2002	3/21/2003	88	6/21/2003	900	(0.24)	(1.93)	1.67	(0.24)	(0.08)	0.06	(0.15)
3/24/2003	6/20/2003	88	9/20/2003	875	(0.16)	1.34	(0.62)	(0.16)	0.03	(0.03)	(0.20)
6/23/2003	9/19/2003	88	12/20/2003	995	(0.13)	(1.28)	1.52	(0.13)	(0.05)	0.02	(0.07)
9/22/2003	12/19/2003	88	3/20/2004	1,025	(0.15)	(1.40)	1.92	(0.15)	(0.07)	0.00	(0.08)
12/22/2003	3/19/2004	88	6/19/2004	1,100	(0.11)	(1.09)	1.86	(0.11)	(0.06)	(0.00)	(0.06)
3/22/2004	6/18/2004	88	9/18/2004	1,100	(0.12)	1.61	1.73	(0.12)	0.06	0.12	(0.17)
6/23/2004	9/17/2004	86	12/18/2004	1,135	(0.10)	0.09	0.09	(0.10)	0.01	0.01	(0.12)
9/20/2004	12/17/2004	88	3/19/2005	1,125	(0.10)	1.62	1.62	(0.10)	0.05	0.11	(0.16)
12/20/2004	3/18/2005	88	6/18/2005	1,200	(0.10)	1.98	1.98	(0.10)	0.05	0.11	(0.16)
3/21/2005	6/17/2005	88	9/17/2005	1,175	(0.10)	(1.01)	1.62	(0.10)	(0.03)	0.03	(0.06)
6/20/2005	9/16/2005	88	12/17/2005	1,225	(0.10)	(1.46)	1.84	(0.10)	(0.05)	0.00	(0.05)
9/19/2005	12/16/2005	88	3/18/2006	1,225	(0.11)	(1.52)	1.66	(0.11)	(0.05)	0.01	(0.05)
12/19/2005	3/17/2006	88	6/17/2006	1,250	(0.10)	(1.24)	1.99	(0.10)	(0.06)	(0.02)	(0.04)
Average					(0.15)	(0.88)	1.59	(0.15)	(0.04)	0.03	(0.11)

Portfolio Strategy 1 (P1): Hold – only hold the Index in the portfolio
Portfolio Strategy 2 (P2): Replacement– replace each unit of the Index with one Call option and T-bills (remainder)
Portfolio Strategy 3 (P3): Straddle – replace each unit of the Index with one Call, one Put and T-bills (remainder)
Portfolio Strategy 4 (P4): Covered Call – hold the Index, and for each unit of the index, short one Call and buy T-bills with proceeds