SILVER CREEK
CAPITAL MANAGEMENT

PORTFOLIO CONSTRUCTION FRAMEWORK

OCTOBER 27, 2016

Introduction

"What is the optimal portfolio?" A question that has been discussed and debated since Harry Markowitz introduced modern portfolio theory (MPT) in his 1952 essay "Portfolio Selection." While practitioners continue to look for ways to improve upon MPT, the underlying concept of the efficient frontier remains a cornerstone in portfolio theory. By using MPT, we can compare different portfolio configurations and see how adjusting for return and risk changes the allocation to each fund.

> "Art and science encounter each other when they seek exactitude."
> *– Étienne-Jules Marey*

Methodology

Prior to diving into our methodology, a number of assumptions and limitations to the process are worth highlighting.

Sample Size – For purposes of this exercise, we chose 8 funds that are well-known to Silver Creek. The time series for each of the 8 funds differs in length with the longest data set starting in 2004 and the shortest data set starting in 2010. In order to be uniform across time series, we decided to start all of the funds' data sets in 2010. While this is a relatively small sample size for each fund of just over 60 data points, we felt it best to standardize the time series for the sake of comparison. However, it is worth noting that a larger sample size may deliver materially different results including the potential for a non-normal distribution.

Normal Distribution – A basic assumption of MPT is that returns follow a normal distribution. Of the 8 funds selected, 5 exhibited relatively normal return distributions and 3 demonstrated non-normal distributions. For research and consistency purposes, we assumed a normal distribution given that 5 of the 8 funds displayed this characteristic.

Historical Data – The underlying concept of MPT is to maximize expected return for a given level of risk. However, in practice, predictions are based on historical data, which does not take into account environments that did not exist. Given that it is impossible to predict the future, we must consider other factors when constructing a portfolio. For example, we may increase the allocation to a manager with whom we have experience as we have more confidence in their ability to meet their expected return. On the other hand, we may look to grow with a newer manager in order to build our conviction.

Other Factors – In the context of a broad portfolio, we must also consider the role a fund plays, as well as how the fund performs in various market conditions. For example, although a fund's return expectations are at the lower end of the spectrum, it may show minimal correlation to any of the other funds in the portfolio. As another example, we could allocate to a fund or strategy if it has proven to be uncorrelated in specific markets. For example, CTAs, at times, have performed well during crises. Although there is no guarantee that this strategy will generate returns in these environments, it may be prudent to have an allocation to CTAs as potential protection in difficult markets.

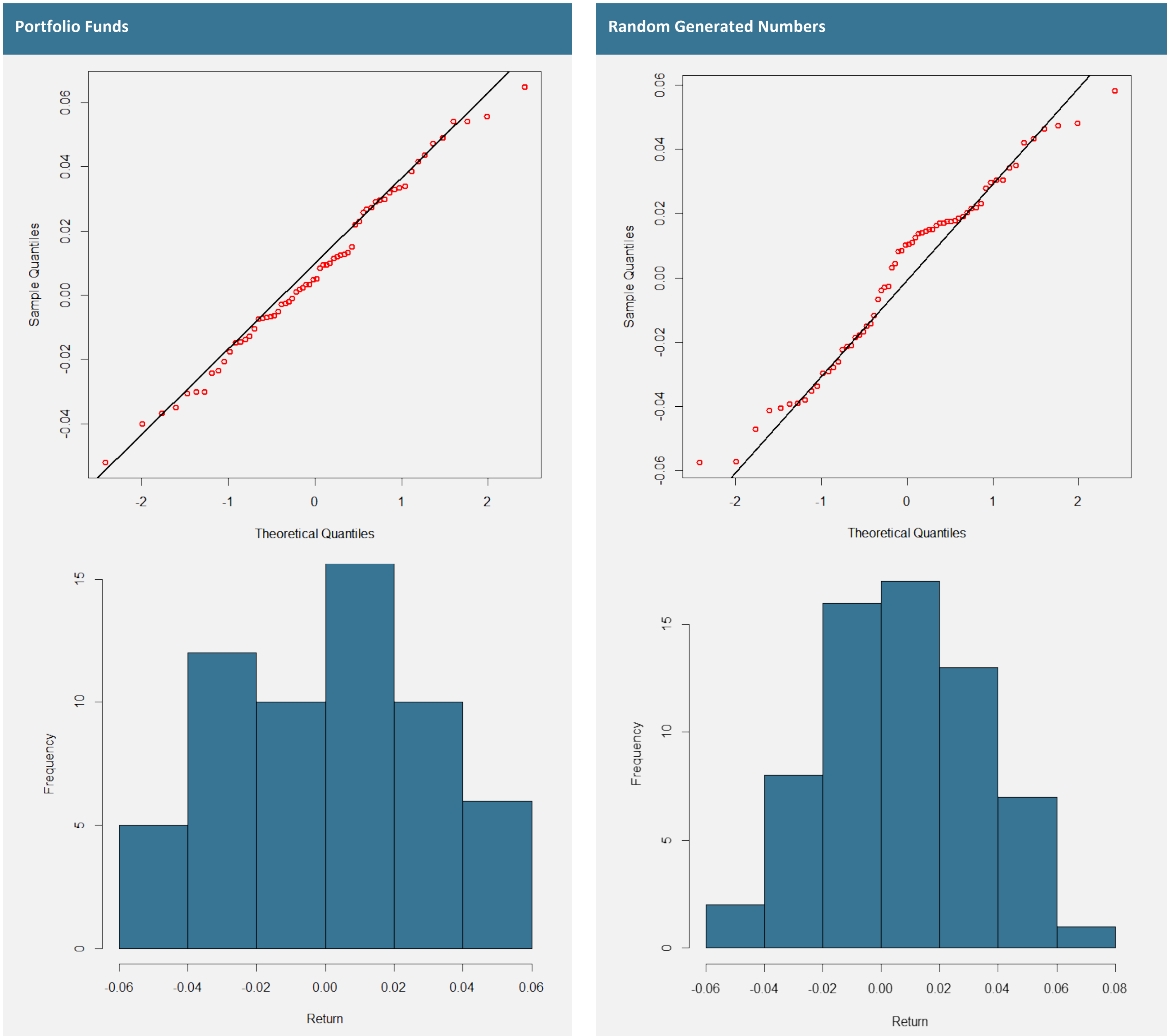
AUTHORS:

Theodore Liu, CAIA
Director of Investment Research
theo@silvercreekcapital.com

Simeon Yu
Risk Manager
simeon@silvercreekcapital.com

Kennan Adams
Investment Analyst
kennan@silvercreekcapital.com

As noted above, one of the major criticisms of MPT is that the theory assumes a normal distribution. In order to see if the 8-fund portfolio satisfied this assumption, we analyzed each of the funds. For reference, the QQ plot (a plot of quantiles of the first data set against the quantiles of the second data set) and return distribution of one of the funds is shown below.



Overall, the QQ plot of the funds fits the normal distribution of the QQ line well with only a few outliers compared to the plot of random generated numbers. Although there is some skewness to the right of the return distribution, the funds' returns generally resemble a normal distribution. Given that 5 of the 8 funds exhibited a similar distribution, we decided to assume a normal distribution for research purposes. While we understand that this has limitations, we felt it best to be consistent across all 8 funds, particularly given that more than half displayed this characteristic.

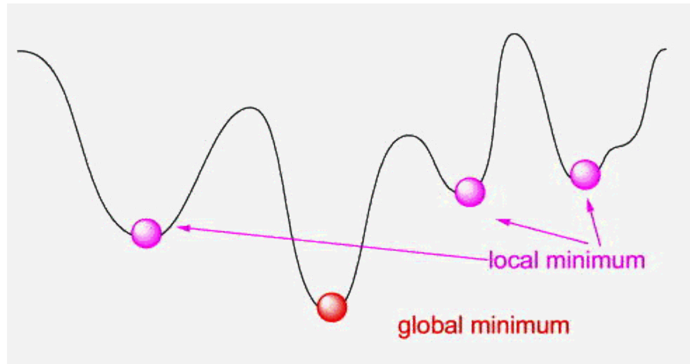
Mathematically, there are multiple ways to construct the optimization process with the most popular being non-linear programming, which comes with a utility function to describe the objective of the optimization and constraints. By taking the standard mean-variance portfolio optimization, the formula can be represented as follows:

$$\text{Maximize } \mathbf{r}^{\mathrm{T}} * \mathbf{w} - \lambda * \mathbf{w}^{\mathrm{T}} * \Sigma * \mathbf{w}$$
$$\text{subject to: } \mathbf{l}_a \leq \mathbf{A} * \mathbf{w} \leq \mathbf{u}_a$$

$$\mathbf{r} = \text{return vector}$$
$$\mathbf{w} = \text{portfolio weight}$$
$$\Sigma = \text{covariance matrix}$$

$$\mathbf{A} = \text{coefficient matrix for linear constraints}$$
$$\lambda = \text{coefficient of risk aversion}$$

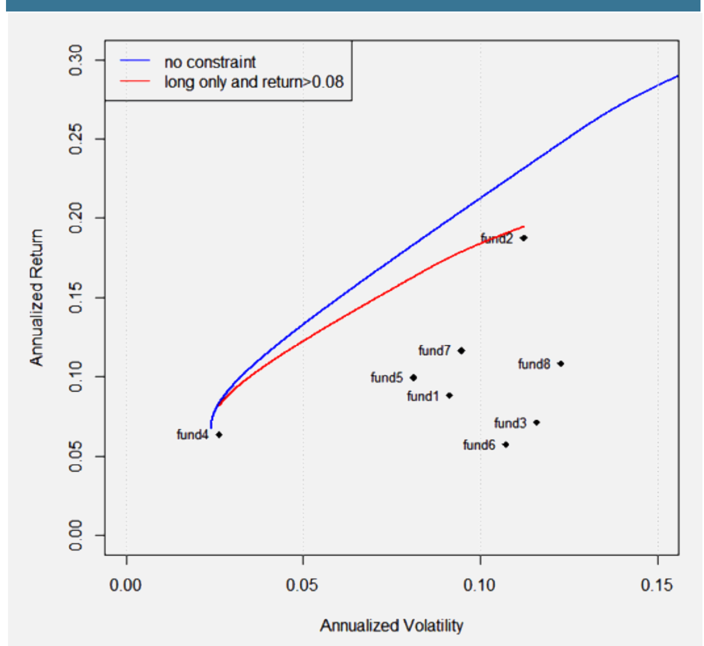
An optimal portfolio can be built to satisfy different return appetites and risk aversions. However, an unconstrained efficient frontier is of limited use as there are other factors to consider as previously discussed. In addition, the unconstrained efficient frontier can utilize short positions if it is determined to be necessary for an optimal portfolio. Given that it is impossible to short a fund, we must build in constraints to the efficient frontier. In this graph, we compare the unconstrained efficient frontier to a constrained efficient frontier, which only takes long positions and requires a portfolio return above 8%.



Given the differences in efficient frontiers, this analysis must be overlaid with the portfolio's investment objectives. While it is convenient to build an optimized portfolio based solely on risk-return objectives, other scenarios must also be considered, which may not be linear combinations of return and risk. For example, maximum Sharpe Ratio or minimum expected tail risk should be analyzed. However, as these are non-linear, these scenarios can be optimized using the extrema among portfolios on the efficient frontier or other utility functions. One of the potential pitfalls in optimizations is that the process can return a local minimum (i.e. a point where the function value is smaller than at nearby points, but possibly greater than at a distant point in the search space).

In order to ensure that our optimization process captures the actual optimal portfolios, we cross validate the different scenarios.

Unconstrained Efficient Frontier vs. Constrained Efficient Frontier



Process

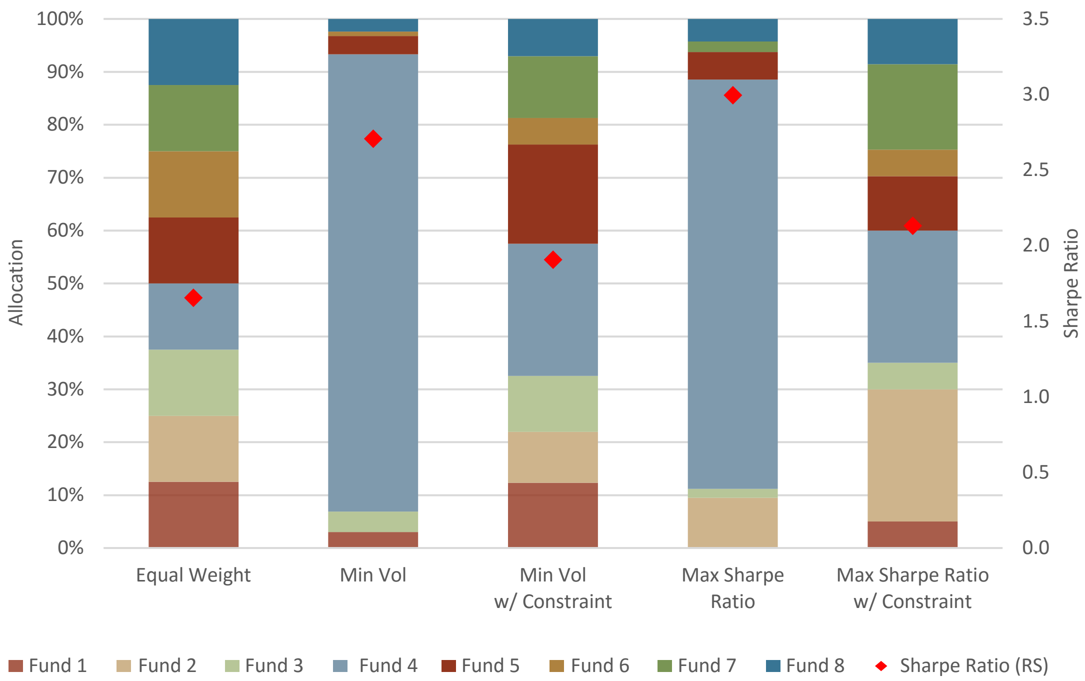
The funds chosen for this exercise are highly diversified with hundreds, and perhaps even thousands of underlying positions, which allows managers to construct portfolios with minimal correlation to broad markets. While this is compelling, it does not account for a fund's correlation to factor exposures (e.g. momentum, value, quality), which can appear in funds from time to time. As it is difficult to know when this could occur, the risk can be mitigated through diversification across 8 funds with low pairwise correlation.

	Fund 1	Fund 2	Fund 3	Fund 4	Fund 5	Fund 6	Fund 7	Fund 8
Fund 1	1.0							
Fund 2	0.4	1.0						
Fund 3	0.3	0.3	1.0					
Fund 4	0.0	0.1	-0.1	1.0				
Fund 5	0.6	0.3	0.2	0.0	1.0			
Fund 6	0.5	0.3	0.3	-0.1	0.7	1.0		
Fund 7	0.3	0.3	0.3	0.1	0.5	0.4	1.0	
Fund 8	0.2	0.1	0.3	-0.1	0.4	0.5	0.3	1.0

In order to help determine the allocation to each fund, we analyzed 5 scenarios including:

- Equal Weight
- Minimum Volatility
- Minimum Volatility with Constraint
- Maximum Sharpe Ratio
- Maximum Sharpe Ratio with Constraint

The constraint used was that each fund allocation must be greater than 5%, but less than 25% of the portfolio.



	Equal Weight	Min Vol	Min Vol w/ Constraint	Max Sharpe Ratio	Max Sharpe Ratio w/ Constraint
Return	10.2%	6.8%	9.9%	8.2%	11.7%
Vol	6.0%	2.4%	5.1%	2.6%	5.3%
Sharpe Ratio	1.7	2.7	1.9	3.0	2.1

Equal Weight - While Equal Weight is the simplest with arguably the least overfitting, it also resulted in the lowest Sharpe Ratio as the annualized volatility was the highest of the 5 scenarios.

Minimum Volatility - Based on the historical return for each of the 8 funds, this scenario was designed to generate the lowest annualized volatility. Although the Sharpe Ratio was high, the annualized return was the lowest relative to the other scenarios. In addition, the scenario significantly over-weighted Fund 4, which had the lowest annualized volatility.

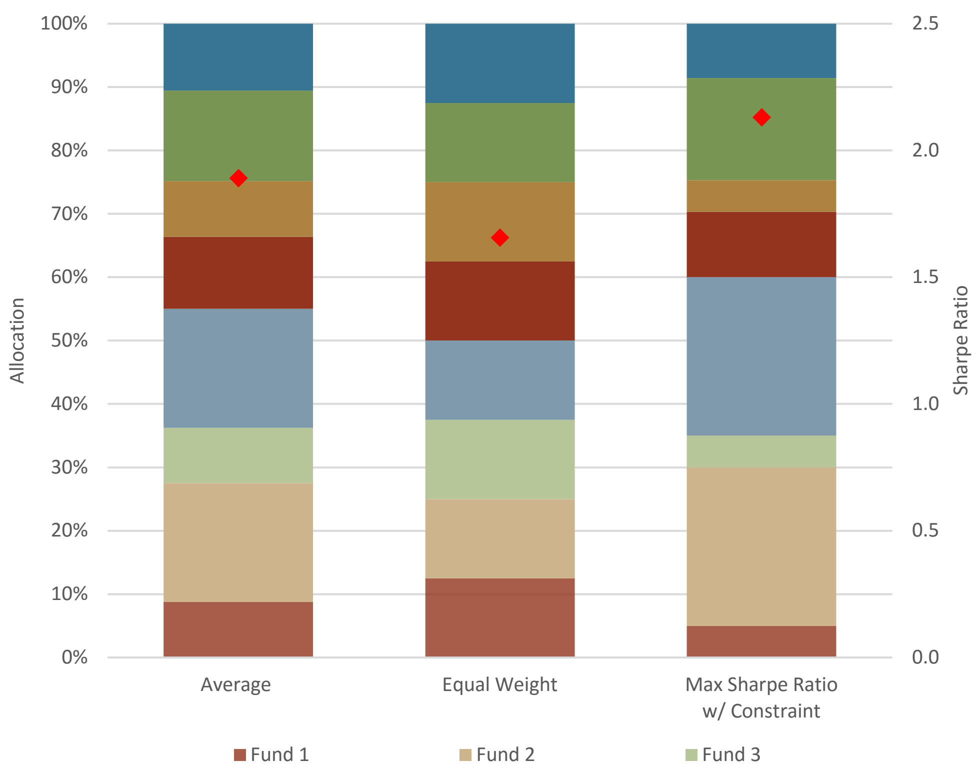
Minimum Volatility with Constraint - By constraining the scenario, the annualized volatility doubled, which resulted in a lower Sharpe Ratio as the annualized return did not increase proportionally to the increase in risk. While Fund 4 was still oversized, the allocation to each of the remaining funds was more balanced.

Maximum Sharpe Ratio - This scenario was constructed to produce the highest Sharpe Ratio using historical returns for each of the 8 funds. Similar to Minimum Volatility, Fund 4 was by far the largest allocation as it had the highest historical Sharpe Ratio.

Maximum Sharpe Ratio with Constraint - While constraints were used, this scenario resulted in the highest annualized return, as well as the highest Sharpe Ratio relative to the other constrained scenarios (i.e. Equal Weight and Minimum Volatility with Constraint). Allocations were reasonably balanced though there was still some concentration risk with the top 4 fund allocations totaling 76% of the portfolio.

Conclusion

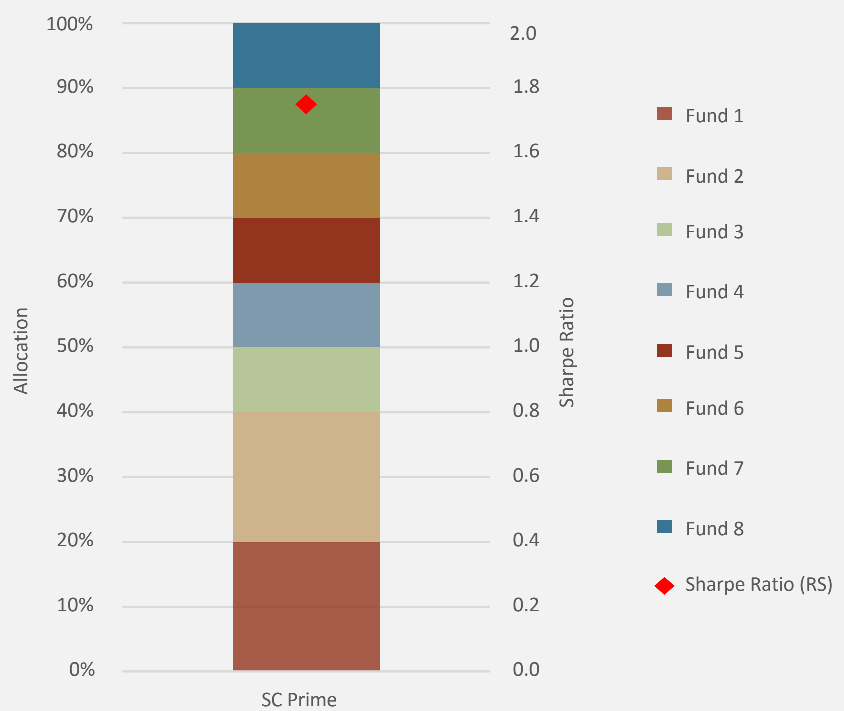
After analyzing the 5 scenarios, Minimum Volatility and Maximum Sharpe Ratio were ruled out as it is highly unlikely that one would significantly overweight one fund. While Minimum Volatility with Constraint was interesting, Maximum Sharpe Ratio with Constraint compared more favorably with a higher Sharpe Ratio and annualized return with minimal increase in annualized volatility. Although Equal Weight had the lowest Sharpe Ratio of the scenarios, it was also the most "intellectually honest" as overfitting can easily occur when using historical data. In other words, if we were to rely solely on optimizing based on risk and return, it may make sense to equal weight the funds as it is difficult to predict future risk and return. However, as noted above, there are a number of other factors to consider. By equal weighting funds, we would be placing little to no emphasis on manager experience and investment strategy, which is one of the dangers of the optimization process.



As both Equal Weight and Maximum Sharpe Ratio with Constraint were attractive, a simple conclusion may be to average the allocations resulting from these scenarios, which resulted in the following:

	Average	Equal Weight	Max Sharpe Ratio w/ Constraint
Return	10.8%	10.2%	11.7%
Vol	5.5%	6.0%	5.3%
Sharpe Ratio	1.9	1.7	2.1

This portfolio was composed of 2 larger fund allocations with the remainder balanced across the other 6 funds. Using this as a starting point, we hypothetically assigned 2 allocations a weight of 20% each and 6 a weight of 10% each. Fund 1 was assigned a larger allocation relative to the other scenarios given the manager's track record and experience managing its strategy. Although Fund 4 was attractive on a volatility and Sharpe Ratio basis, its historical returns are at the lower end of the spectrum relative to peers. However, given its correlation and risk characteristics, Fund 4 can provide the portfolio strong diversification benefits. The remaining allocations were relatively in line with the average of Equal Weight and Maximum Sharpe Ratio with Constraints with adjustments made based on the factors discussed above. While this is a hypothetical portfolio, the combination of quantitative and qualitative methodologies is essential to Silver Creek's portfolio construction framework.



	SC Prime
Return	6.2%
Vol	10.9%
Sharpe Ratio	1.8

Important Disclosures:

This document is for informational purposes only and does not constitute an offer or a solicitation of an offer to buy an interest in any fund (each, a "Fund") managed by Silver Creek Advisory Partners LLC and/or any affiliated management company thereof, including without limitation Silver Creek Capital Management LLC (collectively, "Silver Creek"). Offers are made only pursuant to the Confidential Offering Memorandum and the Subscription Documents of the Fund, which should be read in their entirety. Hedge fund investments may be speculative, highly leveraged, illiquid and subject to a substantial risk of loss, and as a result are not suitable for many investors. Funds are intended only for sophisticated investors who are able to assume the risks inherent in investment vehicles of this type and who meet the Funds' eligibility requirements. **No assurance can be given that any of the Funds will achieve their investment objective or any particular level of returns. An investor may lose money by investing in any of the Funds. Past results of Funds are not necessarily indicative of future performance, and performance may be volatile.**

Silver Creek does not necessarily have access to information from third-parties to ensure the accuracy of the information presented, and any information received from such third-parties. Certain information presented is of a high-level, summary, condensed and aggregated nature, and is inherently limited, incomplete, and required the application of simplifications, generalizations and assumptions to produce. Individual reviews may vary due to Silver Creek's assessment of the risks and other factors associated with the underlying manager. Silver Creek expressly disclaims any representation or warranty as to the accuracy, completeness, availability or timeliness of the information presented. The information provided does not necessarily reflect the most up to date or current information available.

Any statements herein that are not based on historical fact, including without limitation, internal rate of return targets, return targets, future distributions and expected maturity dates, are forward-looking statements. The words "target", "project", "plan", "forecast", "anticipate", "estimate", "intend", "expect", "should", "believe" and similar expressions also identify forward-looking statements. Forward looking statements present Silver Creek's expectations, beliefs, plans and objectives regarding future financial performance, and assumptions or judgments concerning such performance. Although such statements are based on Silver Creek's current estimates and expectations, and known and/or currently available financial and economic data, forward-looking statements are inherently uncertain. There are a variety of factors that could cause business conditions and performance to differ materially and adversely from what is contained in our forward-looking statements. Silver Creek disclaims any obligation to update forward-looking statements. For a description of some of the factors that could cause actual results to differ from our forward-looking statements please refer to the "Risk Factors" in the fund's Confidential Offering Memorandum.

As of the date of this document, the proposed investment vehicle referred to in this document has not been launched. No assurances can be given that any such vehicle will be launched or that, if any such vehicle is launched, it will resemble the vehicle outlined in this document. No assurances can be given that any prospective plans, aims, assumptions, expectations and/or goals, including specific investment allocations, described in this document will be realized. No assurances can be given that specific underlying investment funds will have capacity for the vehicle proposed in this document at the time it is formed. If any such vehicle is formed, the terms of such vehicle will be outlined in the offering memorandum for such vehicle and all of the information in this document will be qualified in its entirety by the information outlined in such offering memorandum. Information contained in this document, including without limitation any description of an investment vehicle and/or the management, investment process, and strategies utilized for such vehicle, may be changed or updated at any time without notice to recipients of this document. Actual processes may vary due to Silver Creek's assessment of the risks and other factors associated with the underlying investment.

By accepting receipt of this document, you hereby agree and acknowledge that the information contained herein (the "Confidential Information") is strictly confidential and may not be reproduced or distributed in any manner. You agree to not disclose any Confidential Information to third parties, except as provided below. You may only disclose Confidential Information upon a good faith determination that such disclosure is required by judicial or other governmental order or as otherwise required by law, provided that you have given reasonable notice to and shall consult with counsel of Silver Creek prior to such disclosure and you shall comply with any applicable protective order or equivalent. You may disclose Confidential Information to your employees or legal and financial advisors on a need-to-know basis.