

# Are Long-Short Equity Strategies Superior?

Richard O. Michaud

*Equity analysts and asset managers often focus on which stocks to buy rather than which stocks to sell. Consequently "sells," or overvalued stocks, may be perceived as relatively less efficiently priced. A market-neutral long-short equity strategy may be able to leverage "sell" information more efficiently than a traditional long-only strategy. Claims of the superiority of a long-short investment strategy are often based, however, on misunderstandings of modern investment theory. Increases in active return associated with the strategy are typically accompanied by increases in active risk.*

*Given the level of information in most institutional stock forecasts, the implied level of portfolio risk, additional costs and available alternatives, many long-term institutional investors may prefer traditional long-only strategies. Long-short investing may be most appropriate as a special-situation strategy.*

**S**uppose you have a reliable forecast of the performance of a universe of stocks. Traditionally you would use the information to buy, or "go long," a portfolio of undervalued stocks. Proponents of a long-short strategy argue that there is valuable information in the forecast that is not being used. They claim that a long-short portfolio consisting of long positions in undervalued stocks (a "long" portfolio) and short positions in an equal value portfolio of overvalued stocks (a "short" portfolio), where market risk is minimized ("market neutral"), can achieve twice the expected active return of the conventional long-only portfolio with minimal risk.

This article demonstrates that claims of the superiority of long-short investing often reflect misunderstanding of basic concepts of modern investment management and may result in unrealistic expectations. Analysis of portfolio risk reveals that the increases in expected return gained by long-short investing are generally accompanied by comparable increases in risk. Additionally, the active risk level of long-short strategies is often substantially greater than normal active management and may be incompatible with the objectives of many long-term institutional investors.

The argument ignores some practical considerations, such as increased trading costs and the likelihood of large losses, that can have a significant negative effect on the performance of long-short portfolios. The discussion focuses on comparing long with long-short active strategies and does not consider the issues raised in a multimanager context.

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*Richard O. Michaud is Senior Vice President of Acadian Asset Management in Boston, a Director of the "Q" Group and a member of the Editorial Board of this journal.*

## LEVERAGE OR RESTRICTED BORROWING

In a long-short strategy, the investor can use the income received from selling short to buy securities. Ignoring transaction costs, the strategy can be self-financing and require no investment. In practice, the investor establishes with a broker an account that requires cash or other securities. Financial frictions limit the level of self-financing. Roughly, a \$100 dollar investment allows the purchase and sale of \$100 in long and short portfolios plus a \$100 investment in a low-risk cash asset.<sup>1</sup> This implies that a long-short strategy is roughly a two-for-one leveraging, or restricted borrowing, process that transforms a \$100 investment into two \$100 equity portfolios. Because the strategy results in two portfolios, it is often described as a "two alpha" strategy.

## Measuring Value Added

As with any active equity strategy, the proper measure of the value added by an active long-short equity portfolio is the amount of residual (active) risk compared with the residual (active) return, both measured with respect to an appropriate benchmark. The level of systematic risk is often irrelevant.<sup>2</sup>

In order to reduce risk, long-short managers often construct "hedged" or "market-neutral" portfolios, which are structured to have minimal market risk. The theoretical absence of systematic risk changes how value added is measured. The residual return in this case is measured with respect to the strategy's cash rate, which is similar to the T-bill rate, instead of the return on an equity index. This is because the minimum active risk position of a market-neutral long-short manager is not investment in an equity index but the absence of investment in equities.<sup>3</sup>

Because there are relatively few long-short equity managers, their relative performances may not be very

reliable. A simple alternative is to measure performance by "equitizing," or adding the return of an appropriate equity index to the residual return generated by the long-short portfolio. This allows comparisons of relative performances across the spectrum of active equity managers.

### Unfulfilled Expectations

A market-neutral long-short portfolio is a hybrid investment strategy: In some ways it resembles normal active equity management, in others fixed-income management. Its paradoxical characteristics can be the source of contradictory claims by managers and unfulfilled expectations for owners of the assets.

A long-short strategy is active equity investment. Capital is invested in equities and the value-added risk and return is active equity risk and return. However, the strategy also resembles cash management. This is because portfolio return is designed to exceed a cash rate, not the return on an equity index. Consequently, an unsophisticated investor may assume that a long-short portfolio provides active equity returns with fixed-income risk. If so, he is likely to be disappointed.

### Short Selling and Long Portfolios

Some managers claim that only long-short strategies both sell overvalued stocks and buy undervalued stocks.<sup>4</sup> Such a statement reflects a serious misunderstanding of basic principles of modern asset management.

Active portfolio risk is defined with respect to overweightings and underweightings relative to index weights. No matter how risk is measured, the index has zero active risk. If the benchmark is the S&P 500, a 50-stock long portfolio is "short" the 450 index stocks not included in the portfolio. Not only long-short strategies but all active strategies are "two alpha" portfolios.<sup>5</sup>

Note that many active managers do not ignore sell information. Modern asset managers assign negative alphas to overvalued stocks and optimization procedures typically lead to underweightings. If some conventional asset managers improperly neglect sell decisions, any inefficiency created is exploitable by many long as well as long-short managers. As many large institutions use modern asset management techniques, it would be surprising if sell information inefficiencies are persistent and economically significant.

In terms of active risk and return, a long portfolio can be described as an "unleveraged long-short strategy." As efficient long portfolios use sell as well as buy information efficiently, the relevant question is: Except for leverage, what's different about long-short portfolios?

### LONG-SHORT STRATEGY RETURNS

By definition, a long-short strategy results in two fully invested portfolios. The return is the difference between the long and short (before shorting) portfolios. Define  $R_{LS}$  as the excess (above the riskless rate) return of the long-short portfolio:

$$R_{LS} = R_L - R_S \quad (1)$$

where  $R_L$  and  $R_S$  denote the excess returns of the long and short portfolios.

In a long-short strategy, the long and short portfolios can be managed separately. The result is that a long-short strategy may be less "index-constrained" than a long-only portfolio; that is, sell information may be reflected in larger underweightings with respect to index weights than in a long-only portfolio. Consequently, a long-short portfolio may enhance the impact of forecast information.<sup>6</sup>

Assume that the excess return of security  $i$ ,  $r_i$ , is consistent with the security market line of the Capital Asset Pricing Model:<sup>7</sup>

$$r_i = \beta_i R_m + \epsilon_i \quad (2)$$

where

$\beta_i$  = beta of stock  $i$ ,  
 $R_m$  = market excess return and  
 $\epsilon_i$  = residual return of security  $i$ .

Let

$R_P$  = portfolio P excess return,  
 $\epsilon_P$  = portfolio P residual return,  
 $\beta_P$  = portfolio systematic risk and  
 $\omega^2 = V(\epsilon_P) =$  portfolio residual risk.

Let  $\alpha_L$  and  $\alpha_S$  represent the *after-shorting* expected residual (systematic risk-adjusted) excess return or "alpha" of  $R_L$  and  $R_S$ . Then:

$$\alpha_L + \alpha_S = E(\epsilon_L - \epsilon_S). \quad (3)$$

Assuming that the forecasting power is symmetric for the top and bottom-ranked stocks, then  $\alpha_L = \alpha_S$  and:<sup>8</sup>

$$\alpha_{LS} = 2\alpha_L. \quad (4)$$

That is, the long-short strategy has twice the long-portfolio alpha.

### Long-Short Strategy Risk

From Equation 2, the total risk (variance) of a long-short portfolio is:

$$V_{LS} = V\{(\beta_L - \beta_S)R_m + \epsilon_L - \epsilon_S\}. \quad (5)$$

Assuming that the long-short portfolio is hedged against market risk and the long and short portfolios have similar risk characteristics, then  $\beta_L = \beta_S$ ,  $\omega_L^2 = \omega_S^2$  and:

$$V_{LS} = \omega_{LS}^2 = 2\omega_L^2(1 + \rho), \quad (6)$$

where  $\rho$  is the correlation of the long and (after-shorting) short portfolio alphas. To simplify further, if the long and short portfolio alphas are uncorrelated, then:

$$\omega_{LS}^2 = 2\omega_L^2. \quad (7)$$

Do these results imply that the strategy is an economic free lunch? While total risk may decrease, Equations 6 and 7 indicate that increases in active return are typically accompanied by increases in active risk. The question is

not *whether* active risk is increased by a long-short strategy, but by how much.

Some preliminary data are available for comparing the active risks of long-only and long-short portfolios. Under current market conditions (see the appendix), the residual standard deviation of a typical institutional, active, long-only portfolio can be estimated as 3.5%. Current estimates of the risk of market-neutral long-short portfolios are in the range of 5% to 15%.<sup>9</sup> This indicates that the active risk multiplier for long-short strategies is on the order of three. At the upper range of risk, market-neutral long-short strategies may be nearly as risky as the market. One important implication is that risk adjustment is essential when comparing the performance of long-short strategies with that of long-only strategies.

### Portfolio Gammas

Is the increase in expected active return associated with a long-short strategy advantageous, given the increase in active risk? A natural way of comparing the relative benefits of investment strategies is to compare ratios of expected active return to active risk.

Define the portfolio's gamma,  $\Gamma$ , as the ratio of active return to risk:

$$\Gamma = \alpha/\omega. \quad (8)$$

Under the assumptions in Equations 4 and 6, the ratio of the gamma of a long-short strategy relative to the gamma of the long-only portfolio is:

$$\Gamma_{LS}/\Gamma_L = \sqrt{2/(1 + \rho)}. \quad (9)$$

Equation 9 shows that a long-short strategy improves the active risk/return characteristics of a long portfolio when  $\rho < 1$ . This result can be cited as a rationale for the superiority of long-short strategies.

Unfortunately, long and short portfolio alphas may be highly positively correlated in practice. A long-short strategy is generally designed to extract more active return from a "best forecast" set of alphas.<sup>10</sup> In this case, the alphas used to structure the long and short portfolios are the same. Consequently, the value of  $\rho$  depends on differences in portfolio active weights that are likely to be the same in sign and similar in magnitude.<sup>11</sup> As a result, a long-short strategy may not substantially improve upon the investment characteristics of a long portfolio.

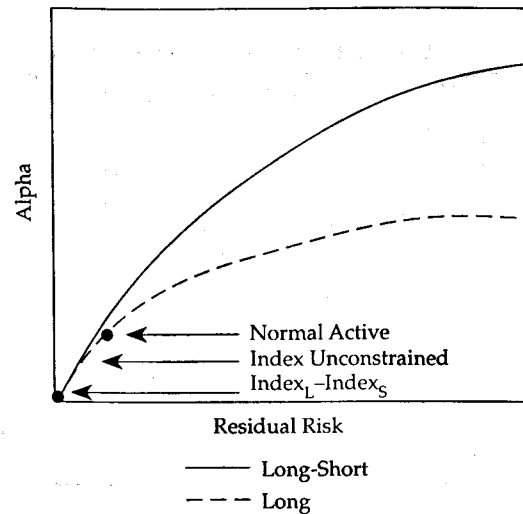
A key to potential benefits is whether and when  $\rho$  is significantly less than one. Proper comparisons of long and long-short strategies require efficient-frontier analysis.

### EFFICIENT FRONTIERS

Consider the residual-risk/return efficient frontier for long-short strategies illustrated in Figure A. The origin, labeled "(long) index—(short) index," is an efficient market-neutral, long-short portfolio with zero active risk. The efficient frontier is labeled "Long-Short" and extends upward from the origin. The long-only residual-risk/return efficient frontier, labeled "Long," curves upward from the origin. Shading indicates where the long

and long-short efficient frontiers differ. The efficient zero residual-risk/return long-only portfolio is the index.

Figure A. Residual Risk/Return Efficient Frontiers for Long-Short and Long Portfolios



The long-only efficient frontier is dominated by the long-short efficient frontier in the sense that, at any given level of residual risk, the long-short efficient frontier will never have less alpha, or a smaller gamma, than the long efficient frontier. In investment terms, long-short portfolios are never more index-constrained than long-only portfolios.

Under reasonable conditions, however, the long-short efficient frontier coincides with the long-only efficient frontier at and near the origin; i.e., for low-residual-risk portfolios.<sup>12</sup> This result is shown in Figure A where the long and market-neutral long-short efficient frontiers coincide in a region that includes the origin. It is only when long efficient portfolios are index-constrained that the two efficient frontiers may deviate.<sup>13</sup>

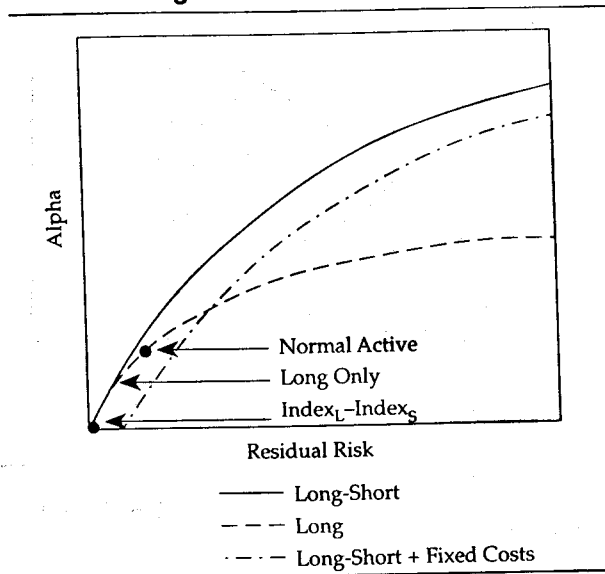
Let NA represent a long-only efficient portfolio with a level of residual risk typical of institutional, "normal" active, risk-controlled portfolios. Assume that the forecasting process is not pathological or inefficient and that NA is near the long-short efficient frontier.

### Fixed Costs and Efficiency

Consider the effect of including the additional costs often associated with managing long-short portfolios.<sup>14</sup> As Figure B shows, when additional fixed costs are included, the long-short efficient frontier shifts downward by a constant amount. The long-short efficient frontier now consists of two segments—the long-only efficient frontier at low levels of residual risk and the long-short-plus-fixed-costs efficient frontier at higher levels of residual risk. This is shown in Figure B with shading below the curve for parts of the frontier that are efficient. Note that typical long-only efficient institutional portfolios, as represented by NA, may be long-short efficient. The results indicate that long-only portfolios are preferable at low levels of residual risk, while

long-short strategies are preferable at higher levels of residual risk.<sup>15</sup> Figure B indicates that, depending on the level of additional costs, even fairly risky efficient long-only portfolios may be long-short efficient.

**Figure B. Residual Risk/Return Efficient Frontiers for Long-Short Portfolios with Fixed Costs**



Without further assumptions, long-short strategies are not inherently more efficient than or superior to long-only portfolios. They are simply part of the continuum of active investment strategies. They represent an extension of the investment opportunity set that may increase after-fixed-costs gamma at above-normal levels of active risk.

### MARKET NEUTRALITY AND OPTIMIZATION

In the context of the long-short strategy, market risk is uncompensated, hence reduces the attractiveness of the strategy. However, market neutrality is not easy to achieve; few portfolios are truly market neutral.

While eliminating systematic risk is straightforward conceptually, it is less simple in practice.<sup>16</sup> Controlling long-short portfolio risk using commercially available optimizers can be an unstable process, requiring a level of precision that may be beyond the current capability of many optimization algorithms and risk models. Also, the risk added by deviations from market neutrality can be difficult to measure *ex ante*.

The optimization process typically creates downward-biased estimates of the optimized portfolio's true risk characteristics. This is because optimizers maximize errors by overusing statistical estimates of small variances and small or negative correlations when minimizing risk. The end result is that "optimized" portfolios often have significantly more risk than estimated. Market risk may thus be a substantial part of the risk of many "market-neutral" long-short portfolios.

A related issue is whether market neutrality is conceptually consistent with active management. Market neutral implies that the portfolio is not exposed to

systematic risk factors. For active strategies based on systematic-risk-factor tilts, truly neutralizing the portfolio's systematic risk may imply that the portfolio has little, if any, active return.<sup>17</sup>

### Forecast Reliability Risk

It is important to note that a long-short strategy does not increase the level of information in a forecast. It does, however, typically increase the level of active risk assumed by an investor. Consequently, a long-short strategy may add substantial "forecast reliability" or "information level" risk to the investment process.<sup>18</sup> A long-short strategy that uses an unreliable forecast can dramatically increase the probability of large losses.

The appropriate level of active risk assumed by an investor should be related to the reliability of the forecast. Given the forecast reliability of many stock forecasts, the level of residual risk typically associated with long-term institutional portfolios may often be optimal.

### Trading Profits

Many long-short managers monitor and alter portfolio structure in real time. Such procedures can reduce margin and cash-reserve costs. Continuous portfolio monitoring also has the potential for capturing trading profits that may be otherwise unavailable. The net effect may be to raise the height of the fixed-cost efficient frontier in Figure B. However, many long-only managers also monitor and trade portfolios in real time.

### Utility Issues

Can long-short strategies be of particular benefit to some classes of investors?

Certain investment styles may be particularly advantaged by long-short strategies. In particular, small-stock portfolios are often index-constrained even at low levels of residual risk. A long-short strategy may enable a small-stock investor to increase active risk. However, potential benefits may be mitigated by the trading costs of shorting small stocks.

One feature of market-neutral long-short strategies is flexibility with respect to asset allocation decisions. A long-short strategy employing bond futures can be used for cash management, for example. Fund policy and active asset allocation decisions can be made independent of the decision to use a long-short manager. The strategy allows unbundling of market timing and stock selection decisions. A critical issue is whether such features are worth the costs and whether suitable alternatives are available. In particular, long-only managers can employ many futures overlay strategies to structure a wide variety of return patterns for various client preferences.

Small pension funds, wealthy individuals and corporate cash managers, for example, may find the strategy attractive, in part because small fund size may limit the consequences of portfolio risk in the context of other sources of wealth.

A short investment horizon limits risk. Traders and opportunistic short-term investors may find a long-short strategy useful.

Finally, the strategy may be an ideal vehicle for

maximizing the impact of *unusually reliable* (presumably short-term) information.

The issue is ultimately one of investor utility. The appropriateness of the risk and return of a long-short strategy can depend on the context of current asset values, liabilities and investment policy. If the objective is simply to increase alpha by increasing active risk, however, many institutional investors have a number of viable alternatives. Active risk can be increased by eliminating investment in passive funds and low-risk asset classes and by increasing the size of funds allocated to normal active managers. The availability of such simple alternatives may affect the attractiveness of long-short strategies for long-term institutional investors.

## CONCLUSION

A long-short strategy is not an economic free lunch. Increases in active return are generally accompanied by increases in active risk. Claims of superiority often reflect misunderstandings of basic principles of modern finance or the hybrid character of the strategy. The investment benefits of the long-short strategy derive primarily from leverage and possible increases in the active return/risk ratio stemming from the use of less index-constrained portfolios. When additional costs are included, efficient long-only portfolios may dominate

long-short portfolios at levels of risk normally associated with institutional active management.

If sell inefficiencies exist, both long and long-short managers are in a position to exploit them, raising the question of the persistence and economic significance of such inefficiencies. If long-short managers have exclusive access to exploitable inefficiencies, it may fall in the domain of trading profits based on real-time portfolio monitoring; however, many long-only portfolio managers also monitor and trade portfolios in real time.

Long-short strategies are part of the continuum of active investment strategies. They may be useful in increasing the reward/risk ratio of relatively high-active-risk portfolios. Because long-short investing does not increase a forecast's information level, however, it may expose an investor to substantial "forecast reliability" risk. Given the current state of investment technology and implied levels of risk, the suitability of the strategy for long-term institutional investors is an open issue.

Long-short investing may be most appropriate for special situations and "niche" investors—that is, for small portfolios, traders and other short-term investors, certain investment styles, and investors with highly reliable information. However, the likely increase in portfolio risk must be considered in the context of objectives, liabilities, costs and alternatives.

## APPENDIX

Let:<sup>19</sup>

- $w_i$  = portfolio weights,  $\sum w_i = 1$ ,
- $b_i$  = index weights,  $\sum b_i = 1$ ,
- $z_i = w_i - b_i$  = over and underweights,  $\sum z_i = 0$ ,
- $z_i^+ = \{z_i \text{ if } >0, 0 \text{ otherwise}\}$ ,  $\sum z_i^+ = c$  and
- $z_i^- = \{z_i \text{ if } <0, 0 \text{ otherwise}\}$ .

The quantity  $\sum z_i^+$  represents investment in the over-weighted or "long" part of an active portfolio;  $\sum z_i^-$  represents investment in the underweighted or "short" part of an active portfolio. By definition,  $\sum z_i^+ = -\sum z_i^- = c$ . For an index fund,  $c = 0$ . From this point of view, a long portfolio is an unleveraged long-short portfolio, which is reflected in the fact that  $c$  is generally much less than one. Because a long-short strategy is typically less index-constrained, the value of  $c$  in the short portfolio of a long-short strategy can be much larger than for a long-only portfolio.<sup>20</sup> The value of  $c$  also depends, in part, on the level of residual risk assumed.

To estimate the residual risk of normal active institutional portfolios, let:

- $R^2$  = portfolio R-squared,
- $\sigma_e$  = portfolio residual risk, or standard deviation,
- $\sigma_M$  = market risk (standard deviation),
- NA = the normal active long-only portfolio.

If:

- $R^2 = 0.95$ ,
- $\sigma_M = 16\%$ , and
- $\beta_P = 1$ ,

then:

- $\sigma_e(\text{NA}) = 3.5\%$  and
- $\sigma_P = 16.4\%$

where

- $\sigma_e = \beta_P \times \sigma_M / \rho \sqrt{(1 - R^2)}$  and
- $\sigma_P = \beta_P \times \sigma_M / R$ .

Based on estimates in footnote 9, there is a reasonable multiplier of the residual risk of a normal active portfolio with respect to a long-short portfolio.<sup>21</sup>

## FOOTNOTES

1. Currently, the actual amount is closer to a \$95 investment in the long and short portfolios. However, \$100 is convenient for explanatory purposes. This assumption tilts the argument in favor of long-short strategies. The difference

between \$100 and the actual amount of the investment leads to an additional fixed cost associated with long-short investing.

2. The notion of measuring the active risk and return of a

short portfolio may not be obvious. Consider the following related question: Does a short index portfolio have any active risk or return? Upon reflection, a short index can have no active risk or return. Consequently, active risk and return in a short portfolio must be measured with respect to negative index weights. Multiplying portfolio weights and index weights by minus one reduces the analysis of a short portfolio's risk and return to the usual long portfolio problem.

3. More precisely, the efficient zero-residual-risk market-neutral long-short strategy is long the index minus (short) the index plus cash. The long and short index positions cancel so that the position is equivalent to no position in equities.
4. See S. Hansell, "The Other Side of Zero," *Institutional Investor*, April 1992.
5. This is a term used in Hansell to describe the allegedly unique but erroneous "two alpha" character of long-short portfolios.
6. Consider the following simple example. A stock index consists of two stocks with the following index weights and alphas:  $i_1 = 0.8$ ,  $i_2 = 0.2$ ,  $\alpha_1 = 2\%$ ,  $\alpha_2 = -8\%$ . Buy stock one is the maximum alpha long portfolio and

$$\alpha_L = 2\% (0.2 \times 2 + (-0.2 \times -8)).$$

Sell stock two is the maximum alpha short portfolio and

$$\alpha_S = 8\% \times -(-0.8 \times 2 + 0.8 \times -8).$$

The long-short strategy alpha is 10%, which is much more than two times the maximum long-portfolio alpha. Long-short investing may improve the reward/risk ratio because it may be less "index-constrained" when reflecting sell information.

7. See W. F. Sharpe "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk," *Journal of Finance*, September 1964 and J. Lintner, "The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets," *Review of Economics and Statistics*, February 1965. The argument does not depend on the validity of any particular model of risk, only that the dichotomy of systematic and residual risk holds.
8. As footnote 6 makes clear, the long and short portfolio alphas need not be equal. However, this assumption is convenient for pedagogical purposes.
9. Estimates by N. Ramachandran, "Using Market-Neutral Strategies to Add Value to Your Portfolio" (*Market-Neutral (Long-Short) Investment Strategies Conference*, Institute for International Research, New York, November 1992).
10. Anecdotal evidence indicates that some long-short managers claim to use different valuation processes for long and short portfolios in order to reduce the value of  $\rho$ . Such a process, if it exists, may have dubious investment value. Whether or not a stock is part of a long or short portfolio would appear to be independent of whether it is over or undervalued.
11. To see this, let  $w^L$  and  $w^S$  denote the active weights in the long and short optimal portfolios. Then, by definition

$$\begin{aligned} \alpha_L &= \sum w_i^L \times \alpha_i \text{ and} \\ \alpha_S &= -(\sum w_i^S \times \alpha_i) = \sum w_i^S \times -\alpha_i = \sum (-w_i^S) \alpha_i \end{aligned}$$

As footnote 6 illustrates,  $w_i^L$  and  $-w_i^S$  have the same sign. More generally, since  $w_i^L$  and  $w_i^S$  will tend to have the

same sign as  $\alpha_i$  and  $-\alpha_i$  respectively, after shorting  $w_i^L$  and  $-w_i^S$  will tend to have the same sign for each security. In many practical cases, the magnitudes will be similar. Consequently, the correlation of  $\alpha_L$  and  $\alpha_S$  is likely to be positive and large. Intuitively, the short portfolio does not alter the overweighting (underweighting) of positive (negative) alpha stocks, but it may allow larger active weights than the long portfolio.

12. The condition that all stocks are in the index and have non-zero positive index weights is sufficient, by continuity, to guarantee the existence of index-unconstrained efficient long-short portfolios at sufficiently low levels of residual risk. This means that the two efficient frontiers coincide at and near the origin. To see this, equitize the market-neutral long-short portfolio by adding an index fund. The residual risk/return of the equitized portfolio is the same as that of the market-neutral long-short portfolio. At zero residual risk, the efficient equitized market-neutral long-short portfolio is not index-constrained, it is simply the index. Consequently, the residual mean and variance is replicable by a long-only efficient portfolio, namely an index fund. By continuity, for sufficiently low levels of residual risk (small neighborhood of the origin), the equitized market-neutral long-short efficient frontier portfolios are not index constrained. Consequently, their (combined) active weights can be replicated exactly by a long-only portfolio. As long-only portfolios can't be more efficient than index-unconstrained long-short portfolios, the efficient frontiers are the same.
13. Note the consistency of this result with the observations made earlier on the gamma of long-short portfolios.
14. Long-short strategies may have a number of fixed, as well as variable, costs not normally associated with long-only asset management. One fixed cost is that operating cash must be set aside for day-to-day management of the short portfolio. Also, long-short managers often have increased infrastructure costs associated with the need to manage twice as many portfolios per \$100 under management as well as specialized procedures for managing short portfolios. The net impact of fixed costs is dependent, in part, on the level of assets under management.
15. The analysis in Figure B does not consider the option of placing a portion of a \$100 investment in a long portfolio and the remainder in a long-short strategy. The net effect of varying the proportion of a \$100 investment in a long-short strategy relative to a long-only portfolio may be to "fill in" the efficient frontier in Figure B. (I am indebted to V. D'Silva for this observation.) While of interest, the issue is essentially related to the multimanager context and is beyond the scope of the paper.
16. See R. Michaud, "The Markowitz Optimization Enigma," *Financial Analysts Journal*, January/February 1989, for discussion of these and other optimization issues.
17. I am indebted to F. J. Gould for this perception.
18. I am indebted to Robert Michaud for this observation.
19. See C. B. Garcia and F. J. Gould, "The Generality of Long-Short Equitized Strategies," *Financial Analysts Journal*, September/October 1992, for further details.
20. See footnote 6.
21. I thank F. J. Gould, Robert Michaud, V. D'Silva, J. Scott, R. Ferguson and D. Stein for their helpful comments.

