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The Law of Large Numbers: An Analysis of the Renaissance Fund

A case study in hedge fund replication and risk management

The Law of Large Numbers, one of the last great gifts of the Renaissance, was first described by Jacob Bernoulli as so simple that "even the stupidest man instinctively knows it is true[1]." It then took him over twenty years to derive a rigorous proof of his famous theorem. Some three hundred years later, the same law under a new name "diversification" has found its proof in financial markets. Our analysis of the Renaissance Institutional Equities Fund shows that thousands of trades, based on fundamental signals generated by computer models, can average to a simple combination of factors that mimic the performance of this large and well-known hedge fund.

Background

In the first weeks of August 2007, quantitatively managed funds had been making headlines for higher-than-anticipated losses in increasingly volatile markets. One of these high-profile funds receiving much attention is also one of the largest: the $26 Billion Renaissance Institutional Equities Fund (RIEF), managed by Renaissance Technologies of East Setauket, New York. Renaissance Technologies, started in early 80's by former mathematics professor James Simons and employing a team that includes over 70 PhDs, is also home to the famous Medallion fund, which has an exemplary track record dating back to the 80's. The Medallion fund's 5% management fee and 44% performance fee are head and shoulders above the industry's standard 2/20. Unlike Medallion, RIEF has lower fees, higher capacity of $100B and targets institutional investors.

On August 10th, *Reuters* reported that Simons had sent a letter to the funds' investors stating its July loss to be between -4.0% and -4.5%, and August-to-date losses "in the order of 7%."[1] The refrain from most articles appears to be that either the models broke or, perhaps more likely, that different models in many other quant shops appear to have been advocating similar positions. The need to liquidate these positions while waiting for their models to recover from the markets' paradigm shift could have caused increased systematic exposure at the worst possible time. However, this may only be a part of the story.

Using Dynamic Style Analysis [3], [4] (referred to as "DSA" from this point forward), MPI's proprietary returns-based factor model, and the fund's historical performance data (NAV returns), we performed our own quantitative due diligence analysis on the fund in an attempt to see if some of the losses could (or should) have been anticipated.

Please note, at no time in this analysis are we claiming to know or insinuate what the actual strategy, positions or holdings of this fund were; nor are we commenting on the quality or merits of Renaissance's strategy or that of any other manager. Instead, we are trying to demonstrate how advanced returns-based analysis can be used to better understand fund behavior, anticipate performance, identify risks and, possibly, replicate fund performance in certain cases.

[1] Source: Wikipedia http://en.wikipedia.org

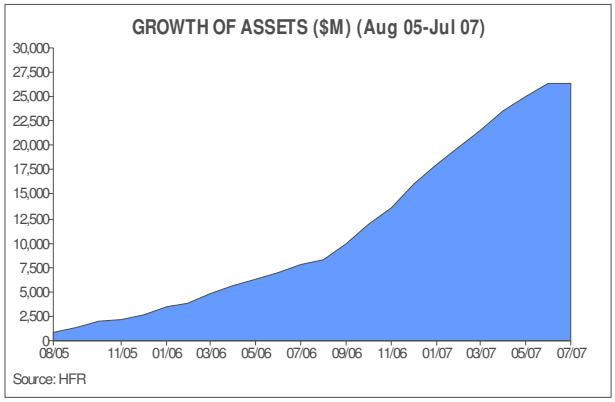
RIEF Strategy Close Up

The following description of the Renaissance Institutional Equities Fund's strategy was retrieved from the HFR database[2]:

RIEF is a quantitative long biased US equities fund that utilizes much of the predictive, risk-modeling, and cost modeling technology of Renaissance's flagship Medallion Fund. RIEF, which is traded completely in accordance with computer models, is designed to add significant value over U.S. equity market indices, with substantially less risk, over a three to five year time horizon. Using proprietary mathematical models of price prediction, covariance, and trading cost, the Fund takes long/short positions in over 3,000 publicly-traded U.S. equity names, with an average holding period over one year. The Fund maintains a $1 net long position at all times, and seeks to limit effective leverage within a narrow band around $1.75 long, $0.75 short. RIEF is not a tracking fund, yet aims to maintain a relatively low volatility of approximately 10.5%, which is approximately 70% of the S&P 500 Index's historical average, and a target beta of about 0.4. While the Fund is permitted to trade stock index futures, the intention is to do so only for the purpose of rapid risk reduction, should that ever be deemed prudent.

Thus, the fund is presented as having low volatility and lower risk than the market and, in today's jargon, represents a 175/75 long-short strategy with a relatively low turnover. It is worth noting that over the past two years the strategy accumulated in excess of $26 Billion in assets (Figure 1).

Figure 1
Renaissance Fund Assets



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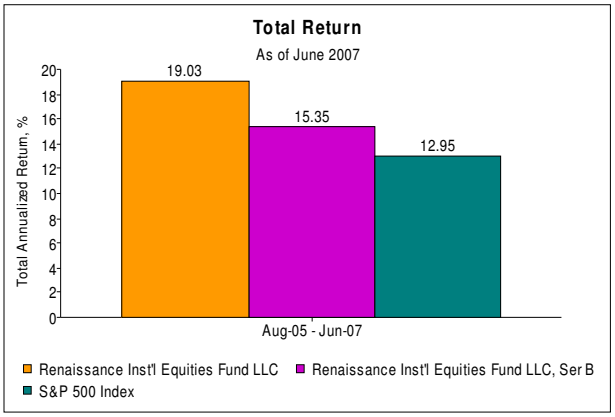
[2] The strategy description as well as asset and performance data were provided by Hedge Fund Research in Chicago, IL (HFR).

Historical performance and risk of the stated strategy are easily verified using the fund's historical returns and those of the S&P 500, since August 2005 (the fund's inception). Annualized returns since the fund's inception through June were 15.35% for their B series (net of fees) and 19.03% gross of fees, compared to 12.95% for the S&P 500 (Figure 2).

Figure 2
Return



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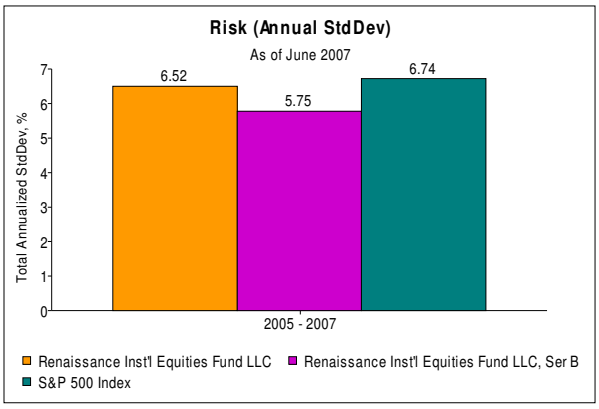
Annualized standard deviation for the same period was marginally lower gross of fees, at 6.52%, compared to 6.74% for the S&P 500 (Figure 3). The remainder of the analysis is conducted using the gross of fees series.

Figure 3
Risk



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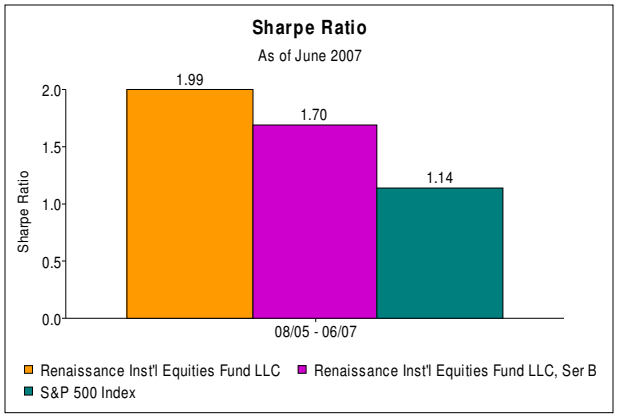
A typical due diligence analysis of such a fund would include calculations of its MPT statistics (alpha, beta, Sharpe Ratio, etc.) along with numerous ratios and gain/loss statistics. The problem with such statistics is that they often have little predictive power, can be misleading and result in a false sense of security – the

last thing a hedge fund investor needs in a time of crisis.

For instance, one may decide to use the fund's beta to estimate its losses in July. Thus, beta vs. the S&P 500 index computed through June is 0.43, and is well in line with the target of 0.4 featured in the fund's strategy description. Given that the S&P return for July was -3.1%, we would have estimated July's return for the fund to be around -1.3%. Since the fund's return was actually less than -4%, it demonstrates once again that low beta of hedge funds has to be taken with a grain of salt. It must be said that low beta values of hedge funds are similar to those of balanced mutual funds such as Vanguard Wellington[3], thus implying lower systematic risk. What is usually neglected is that - compared to mutual funds - corresponding R-squared values are very low for hedge funds (e.g., 20% for RIEF) placing little trust on the beta number itself.

Based on our computations, RIEF Sharpe Ratio through June '07 looked attractive at 1.99 and 1.70 for gross and Shares B net of fees, respectively (Figure 4), compared to that of 1.14 for the S&P 500 Index.

Figure 4
Sharpe Ratio



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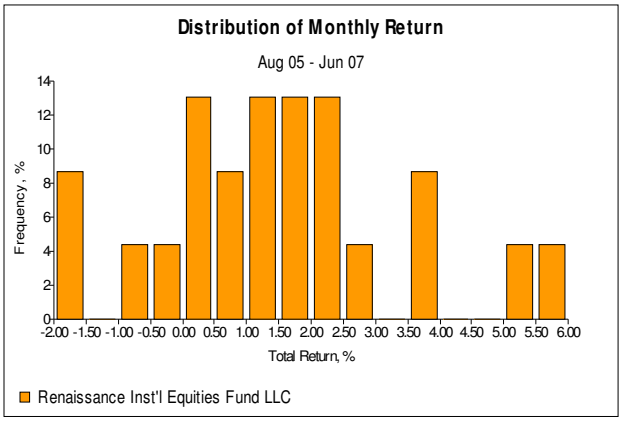
It worth noting that despite its frequent use in hedge fund promotional literature, *ex post* Sharpe Ratio provides very little guidance regarding future fund efficiency, especially for such skewed and non-normal distribution patterns as that of the Renaissance Fund, for which the return distribution histogram is shown in Figure 5.

[3] Wellington's beta vs. S&P 500 Index is 0.6 with the R^2=85%

Figure 5
Distribution of Returns



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Reverse-Engineering the Renaissance

So what analysis does work for such a hedge fund when only a monthly performance track record is available to investors? One of the most effective methods is Returns-Based Style Analysis (or *RBSA*), a regression methodology first proposed by Prof. William Sharpe in the late 1980's to identify a credible combination of systematic market factors that explain or best mimic the fund's performance variability. Although such an approach may not always provide the level of insight one would like, especially in cases where funds are involved in statistical arbitrage and/or employ illiquid securities, Renaissance is a particularly good example because (1) the fund was well diversified, investing in thousands of securities and, more importantly, (2) the strategy was somewhat "directional" with a holding period for stocks of over a year. Both these factors increase the likelihood of having a credible analysis of Renaissance returns.

To better understand what factors are influencing the fund's returns, we use MPI's proprietary returns-based "DSA" technology to perform a dynamic regression of 24 monthly fund returns through July 2007 using corresponding monthly returns on generic market indices as explanatory variables. For this analysis we used 6 Russell Style indices and the MSCI EAFE Index, which was used to sense the fund's exposure to foreign stocks. Since the fund is involved in selling stocks short, we didn't impose any non-negativity constraints (which are typically used in the analysis of long-only products such as mutual funds). We let the model select both the optimal smoothness of exposure paths as well as the limited, most predictive set of factors out of the seven selected. The results shown in Figure 6 depict the market factor weights that best simulate the fund's behavior over time.

Figure 6
Historical Factor Exposures

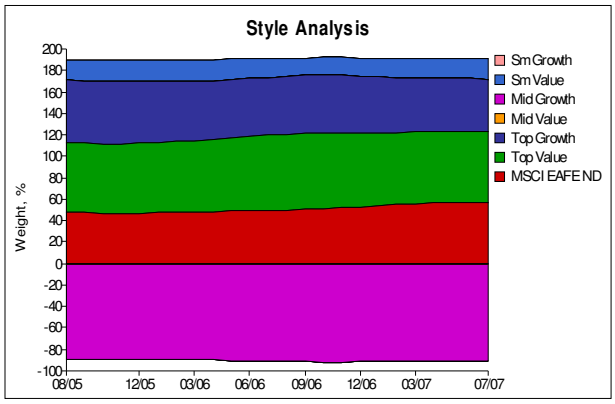

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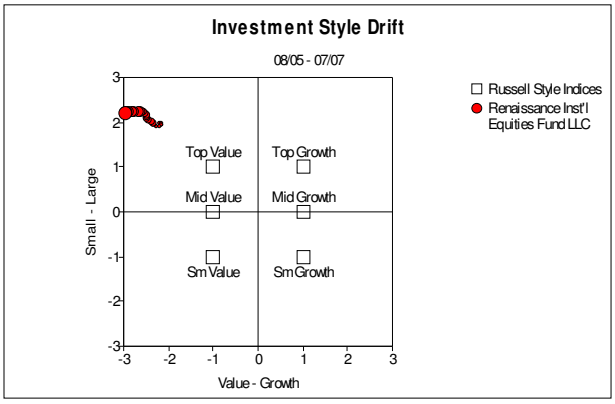
Figure 7
Style Map



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One of the requirements of the returns-based model is that the tracking portfolio of generic indices is fully invested, which is in-line with the fund's description of the strategy. This restriction can be observed in the exposure chart in Figure 6 where long positions (areas above zero, 0) and short positions (areas below zero, 0) add up to 100%. Note that the short position is about 90%, which is consistent with the 75% stated in the fund's profile if we take into consideration that there is some stock and sector overlap among Russell style indices.

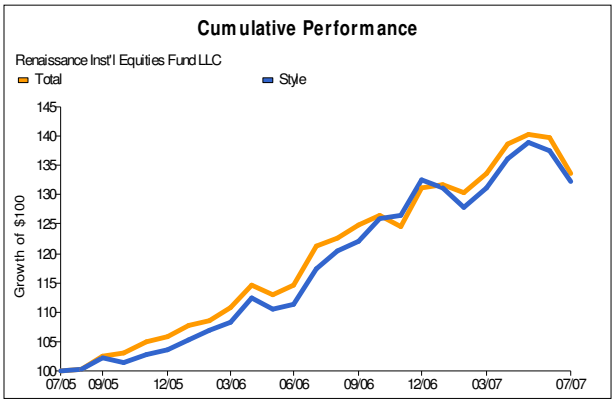
A quick look at long and short exposures tells us that the fund's behavior indicates a leveraging of value stocks at the expense of growth (short exposure is Russell Mid Growth). This is especially evident when analyzing the fund's Style Map in Figure 7. Such maps are derived by displaying historical exposures as dots on the Style-Size plane with Russell indices depicted by squares occupying "corners" of the style space. Thus, exposures of a long-only portfolio would fall within the style square. Once long-only constraints are lifted, the dots are "allowed" to go outside the box to depict leverage. In Figure 7, the Renaissance exposures position the fund well outside the long-only square (the "snail trail" in the upper left corner with the smaller dots representing earlier time periods).

Such a position on the map indicates that the fund behaves as though it has leveraged fundamentals, i.e., its weighted P/B is several times smaller than that of the Russell Value indices and its weighted market capitalization could be significantly bigger than that of the Russell Top 200 Index.[4]

[4] Russell index classification is based on Price-to-book ratio and the I/B/E/S forecast long-term growth mean. Either one or both could be considered leveraged.

Another notable observation from the Exposure chart in Figure 6 is the positive exposure to foreign stocks represented by the MSCI EAFE index. This could indicate an exposure to ADRs – which are, by design, not included in the Russell indices, or simply sensitivity to foreign markets through investing in certain US securities. This is not surprising given similar results from analysis of the HFRI Equity Hedge Index that were noted in [4].

Figure 8
Fund Performance vs. Style Benchmark



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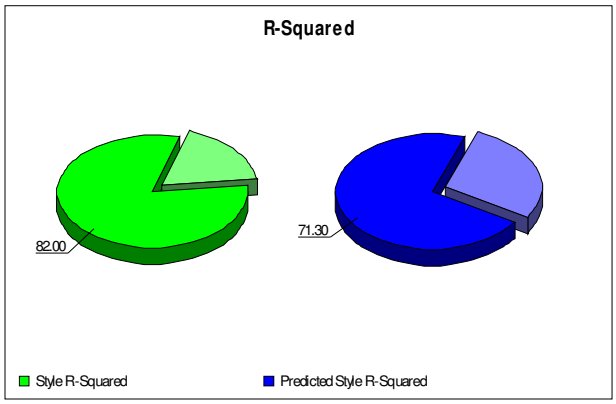
The chart in Figure 8 shows cumulative performance of the fund, compared to the synthetic returns of the "Style" portfolio, created from the exposure weights shown in Figure 6. This Style portfolio is essentially a tracking portfolio created from the five market factors identified by the model. The closeness of the Style portfolio to the actual fund returns is pretty remarkable, especially as the factor exposures haven't changed at all over the two-year period. This adds a lot of credibility

to the analysis, which otherwise could be considered as a fitting exercise.

Another confirmation of the high quality of the analysis is a relatively high Predicted R-Squared, MPI's proprietary credibility measure defined in [3], [4]. As shown in Figure 9, the fit of the fund's performance by the model is 82% (Style R-Squared), while the Predicted Style R-Squared is 71.3%. Such high R-squared values are more common to the analysis of diversified long-only mutual funds. High predictability of results typically implies that this fund's returns could be successfully replicated out-of-sample, which we will attempt to do next.

Figure 9
Credibility of Analysis (R-Squared)



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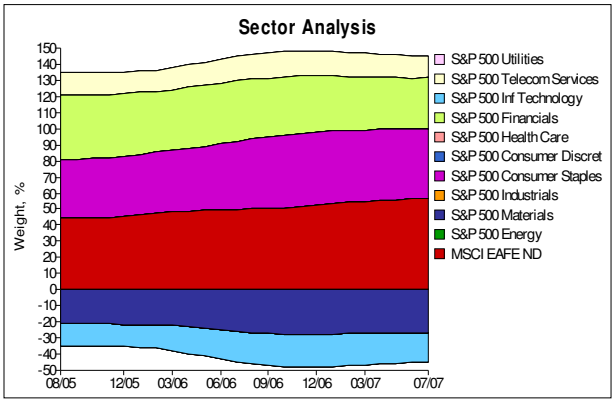
In the previous analysis of the fund we used style indices to determine return sensitivities to stock fundamentals. A similar analysis can be performed using economic sectors. In Figure 10 we show results of such an analysis using the DSA model with S&P 500 Economic Sector indices, depicting residual sensitivities of the fund's long and short positions. The R-Squared's of this analysis are exceptionally high for a hedge fund and stand at 89% and 76% for Style and Predicted Style R-squared, respectively. The pattern of exposures is very similar to that of the previous analysis: steady levels with negative values above the 50% mark. We detect again a significant exposure to international equities (MSCI EAFE). Some of the notable allocations: negative exposure to Technology stocks, positive exposure to Financials and Consumer Staples.

Figure 10
Economic Sector Exposures of the Fund



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Replicating the Renaissance

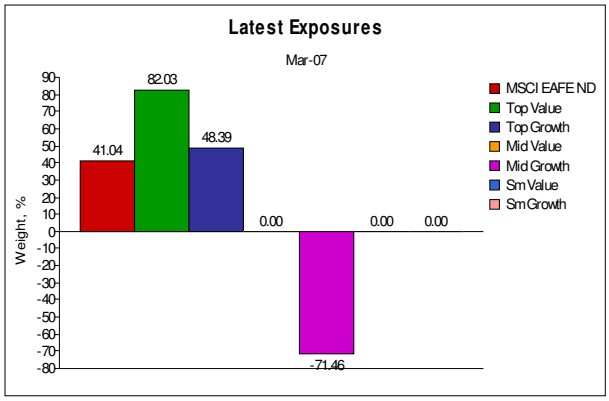
Although there has been a lot of buzz lately about hedge fund replication, the replication idea itself originated a long time ago in the early 1960's with the introduction of Sharpe-Lintner-Mossin Capital Asset Pricing Model (CAPM), where a security return was approximated by a market portfolio and a risk-free instrument. Sharpe's multi-factor RBSA [2] introduced 25 years later moved return replication into the realm of active investment. It provided a robust due diligence on long-only investment products by effectively replicating their track record using long-only portfolios of generic asset indices. It's worth noting that replication of investment instruments these days is performed on a daily basis by scores of traders and market makers hedging their exposures – and all of it without a lot of buzz. Some of the newer approaches that emerged in recent years focus on either replication of the return distribution or fitting a derivative into the return pattern – basically dynamic hedging techniques designed to work with high-frequency daily data.

Multi-factor models such as RBSA and its dynamic hedge fund-oriented cousin DSA work with data of any frequency. They are unique in that they provide both a replication tool and a due diligence tool. Instead of blindly replicating the return distribution of the Renaissance Fund shown in Figure 5 or fitting an option into the time series of 24 monthly returns without any guidance on future long-term results, multi-factor models focus on identifying systematic risk factors that explain the fund's performance.

In order to illustrate this concept, we ran an analysis using the same factors as before with only 20 months of the Renaissance return data through March 2007. The model identified only four relatively stable exposures

as having the most predictive power. In Figure 11 we show exposures as of the end of March 2007, which are very similar to the ones shown in our previous in-sample analysis.

Figure 11
Replication Portfolio Allocations



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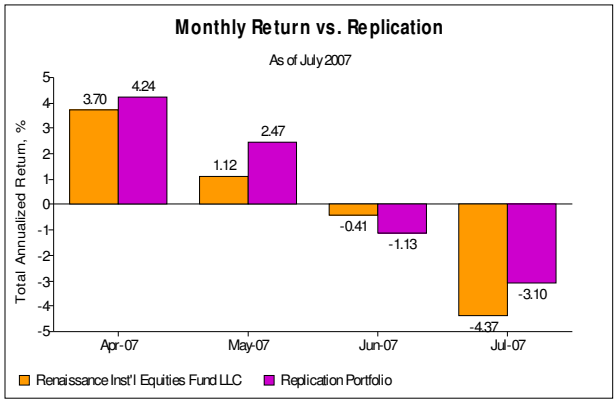
Assuming that the weights were held constant through July 2007, we created a hypothetical replication portfolio of indices using index returns through that month. In Figure 12 and Figure 13 we compare both monthly and cumulative performance of the hypothetical portfolio and the Renaissance fund over the period of April-July. It is evident that the replication portfolio does a decent job in capturing both the direction and the magnitude of the fund's performance: the Replication portfolio lost -3.1% in July compared to the fund's actual loss of -4.37%. Note that such a result was expected given relatively simple and stable exposure structure and high explanatory power of in-sample estimation.

Figure 12
Monthly Returns Replicated



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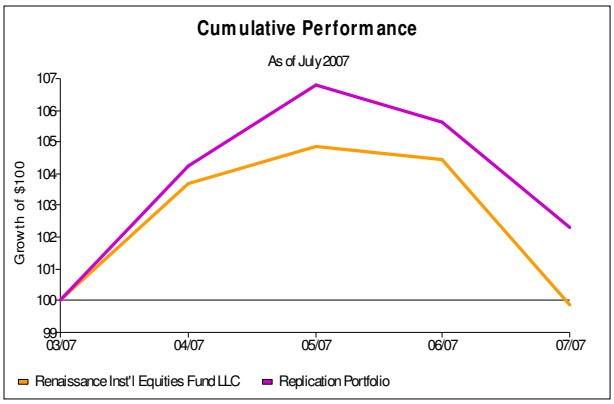
Please note that the Replication portfolio above was held constant and didn't incur any turnover other than monthly rebalancing. In a real-life replication task, such a portfolio would have to be adjusted on a monthly basis to reflect changes in exposure and, in some cases, incur significant turnover if a strategy shift is detected.

Figure 13
Growth of $100 Replicated



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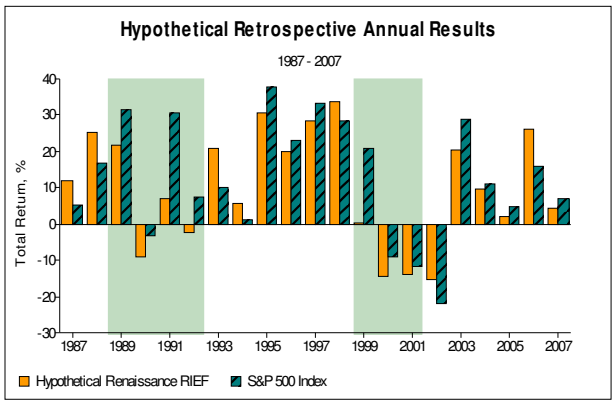
Twenty Years After

Finally, we decided to explore how the Replication (or tracking) portfolio would have fared in various market conditions over the past 20 years - which include bull markets, recessions, bubbles, etc. For funds with a relatively short track record, such "retrospective" analysis provides investors with a valuable and easy-to-interpret stress-testing of the strategy – another benefit of the returns-based methodology.

We first took the same Style portfolio formed by Russell and EAFE indices with weights equal to exposures derived through DSA analysis as of March 2007. We then computed the annual performance track record back to 1987 on this portfolio with the assumption that the weights were held constant over time, i.e., rebalanced monthly. In Figure 14 we compare annual returns of this hypothetical portfolio with the S&P 500 Index. Clearly, this strategy does not work in all market environments. The two periods marked by shaded areas in the chart reflect the most significant prolonged underperformance of the hypothetical portfolio.

During the recession of 1989-92, the hypothetical portfolio underperformed the index for four consecutive years and by about 65% in total. During the technology "bubble" of 1999-2000, it underperformed by about 25%, trailing the index in each consecutive year.

Figure 14
Hypothetical Simulated Performance (Using 20 Years of Index Data)



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Such hypothetical performance is widely used in the returns-based *Value-at-Risk* (VaR) methodology [5] instead of the actual track record for short-lived funds such as RIEF because the latter is not representative of their potential return distribution and associated losses. Thus, distribution of returns in Figure 5 is related to the period of low market volatility and is not indicative of potential returns in varying market conditions. At the same time, market indices that are used to reconstruct the hypothetical track record have longer history and allow for more accurate assessment of risk.

Thus, the fund's monthly 95% VaR computed in March 2007 is equal to 8%, indicating a potential 8% monthly loss during a 20 month period (assuming constant exposures).

Summary

Our analysis shows that quantitative hedge fund strategies are often easier to understand than is commonly thought – despite the associated clout of computer-driven arbitrage. In the case of the highly visible Renaissance Institutional Equities Fund, significant assets under management, a large number of positions and the directional nature of the strategy provided sufficient "diversification material" and inertia for returns-based analysis to get keen insight into the fund's behavior - using only two years of monthly returns.

Proper hedge fund due diligence should go beyond ratios and drawdown statistics which have little predictive power. At the same time, if estimated accurately, factor and/or index exposures of a fund could provide sufficient guidance of what to expect from the strategy in various future market environments. When it comes to the replication of hedge funds, dynamic multi-factor analysis of hedge fund returns provides both the means of replication and sufficient information to decide whether a given strategy should be a replication target in the first place.

Work Cited

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