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Keeping the Devil in Its Box

Using Quantitative Techniques to Manage Risk

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I. Manage Maximum Drawdown using pure quantitative techniques

The 2008 market meltdown and its impact on alternative investment raised two fundamental issues:

- The variable risk transparency of hedge funds and funds of hedge funds – a number of investors have been very surprised by the magnitude of losses they recently experienced; and
- The capability of hedge fund investors to limit their losses in such market conditions, through an extreme risk budgeting policy.

We addressed the first point in our study '*Navigating the Perfect Storm*', which demonstrated that the impact of the market meltdown on hedge funds was predictable, and therefore risk transparency was possible. In the same study, we postulated that appropriate risk transparency could have been achieved at the time, and that it would have been possible for many funds to implement an extreme risk budgeting policy at a reasonable cost. One could object that such a statement seems rather theoretical when facing a real-life situation, due to the following limiting factors:

- Long lock-up clauses on a significant proportion of the portfolio,
- Liquidity management issues, forcing the firing of the most liquid managers when capital resources are shrinking,
- Change in correlations and/or massive style drift when markets are dislocating.

Another objection might be that the price of instituting risk transparency measures would result in less attractive investment returns.

This study seeks to demonstrate that these objections are not valid, as long as:

1. **Extreme risk budgeting is set and managed on a long term basis.** This remains the only way to account for lock up management and liquidity management clauses.
2. **Appropriate nonlinear factor models are used.** It is important to detect hidden risks and to account for systematic changes in correlation, as observed in various market regimes.

Our study demonstrates that setting extreme risk budgets and using appropriate quant models can create strong value, both during periods of "business-as-usual" as well as during phases of market instability. This is possible – by taking more "business-as-usual" type risks, while using cheap and effective hedges to cover extreme risks.

II. Proof: "Out of Sample" results generated with 4 *Portfolio Construction Techniques*

A rigorous out-of-sample testing procedure

In order to assess the possibility of keeping extreme risk under control, we ran a strict out-of-sample back test. We randomly selected three short lists of funds from among those reporting to HFR since at least 2002 (in real life, this would be the result of a qualitative selection process).

We then simulated the construction of a portfolio as if we were an investor willing to limit **the worst month to a loss of 3% with a 99% confidence level**. In other words, we have a 3% budget for the 99% Value-at-Risk of the portfolio. The portfolio reallocation was made **once a year**, with a three month lag before actual implementation; in order to account for potential liquidity constraints.

We tested four different techniques of portfolio construction:

- **Capital allocation**: with this technique, we simply allocate the same amount of money to each manager. We then adjust leverage, so as to insure a monthly volatility below 1.3%.[1]
- **Risk allocation**: we allocate 3% of the risk budget equally on all funds, with the conservative assumption that 100% of funds were correlated.[2]
- **Markowitz**: we simply use the Markowitz optimizer, with a targeted monthly volatility of 1.3% and expected excess returns equal to the past three years of average returns.[3]
- **FOFiX**: in this process, we combine a classical allocation process with a ***tail risk budget of 3%***, set at the extreme level of risk – as measured by our nonlinear factor models.[4]

To render the exercise as realistic as possible, allocation limits were assigned as follows: an absence of negative positions and no allocation exceeding 5% of the assets under management.
To insure that the exercise is comparable with FoF performance indices, we applied a 1.5% management fee and a 15% performance fee, to compute monthly NAV for each of these strategies.
The fact that we used automated portfolio allocation techniques does not imply that we unilaterally- believe in utilizing only quant-driven investment process. Rather, for the purposes of our demonstration, this is the only suitable approach for running a rigorous out-of-sample back test to assess the efficiency of risk management.

[1] The level of volatility requires keeping the worst month below 3% with a 99% confidence interval, assuming a Gaussian distribution. The volatility measure used was equal to the past 3 years of volatility.

[2] Technically, it consists of converting the % risk budget into $ risk, and allocating this equally to each fund. Then the $ allocation on the fund is derived dividing the risk budget by its %99 Monte Carlo Value at risk, as calculated by FOFiX.

[3] Same comments that for 1

[4] Consult Appendix 2 for the full description of this technique.

Demonstrating that tail risk control is both possible and beneficial

If we compare out-of-sample track records of the 4 techniques over time, we obtain these results:

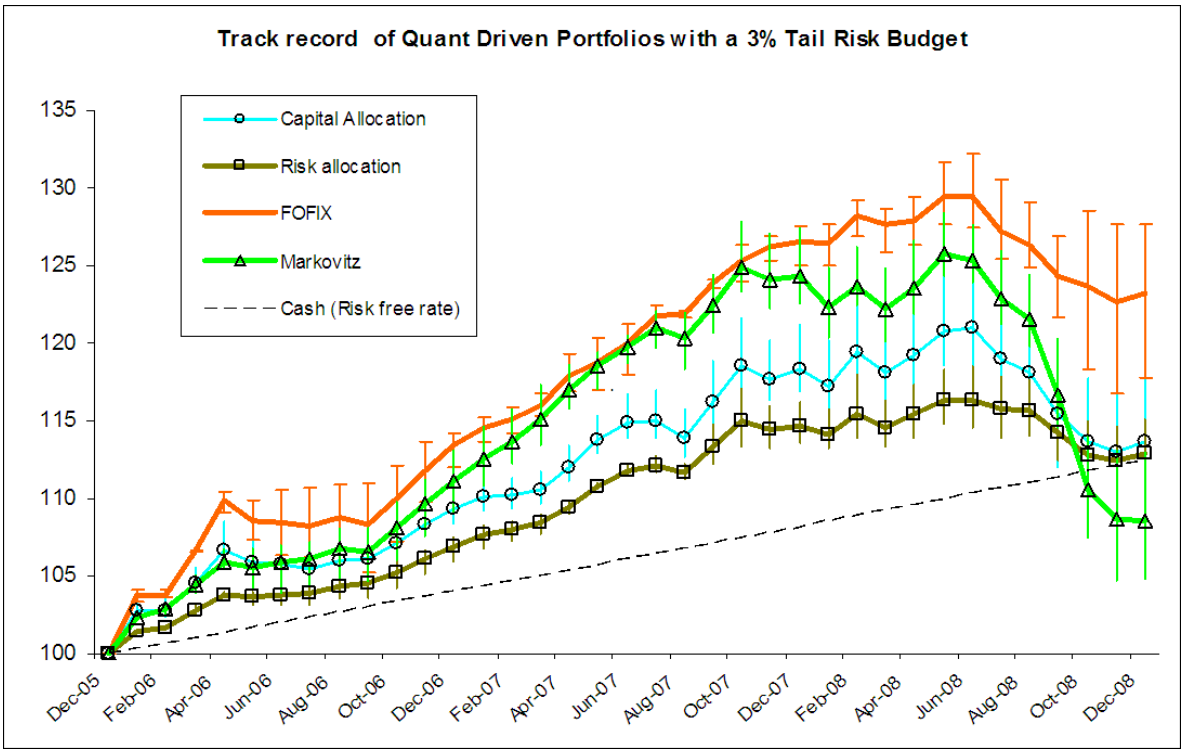


Figure 1: Track records of the different techniques, net fees. The lines represent the average NAV reach for each technique and for the 3 samples. Min and Max are given by the vertical bars.

If we look at the month-by-month performances (the extreme risk limit shown in black), we generate results, as presented in Figure 2 below.

Our conclusions are the following:

- Only the Markowitz technique failed to remain within the risk budget: it exceeded its risk budget 6.5% of the time, whereas it should have exceeded it only 1% of the time (see appendix 1); this is a failure of both ex-post techniques and of that optimization approach which mechanically tends to search for the flaw of the risk model, in place. This presents very poor performance.
- FOFiX's approach is by far the most economical in terms of the "cost of hedging". It strongly outperforms the others options during the period in question – resulting in an outstanding 4.4% excess return over the risk free rate before fees. Moreover, prior to the crisis it also delivers slightly higher performances than the best performing strategy, which means that the cost of hedging is in fact negative!

- Other techniques can work, but at a cost which makes them unattractive vs. investment in cash. However, the risk allocation technique appears to be excessively conservative, with a 1.6% worst month, over the period. This results from the 100% correlation assumption between funds. If one were to relax this assumption, then the risk allocation would perform in a manner superior to that of capital allocation – with a tangible excess return over the risk-free rate, before and after fees.

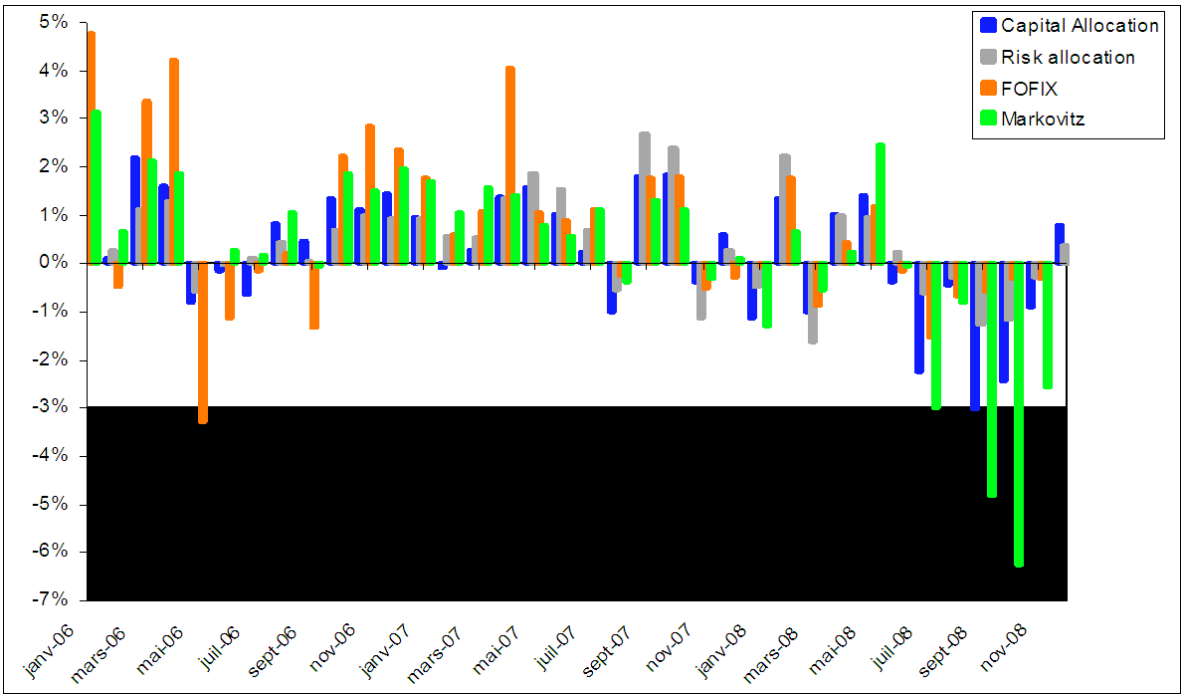


Figure 2 : Month by month performance for 12 test portfolios. Risk budget should only be hit 1% of the time, i.e. one month for just one sample. Markowitz clearly massively failed, capital and risk allocations are too conservative, while FOFiX is right on target.

...to the extent that one captures "hidden risks"...

If we analyze the data further, we see that the main reason why FOFiX succeeded, while Markowitz failed, is FOFiX's capability to spot "hidden" risks.

Hidden risks typically result from 3 phenomena:

- Nonlinearity – (the typical example is a short put, out of the money);
- The "time bomb" effect, i.e. surfing on a risk factor which exhibits very nice patterns when looking back over a short period of time, but in fact happens to be very risky when analyzed over the long term (a typical example is the credit spread);
- Returns smoothing for managers who trade illiquid securities, or who commit fraud.

The FOFiX technique combines all the quantitative indicators to properly spot these risks: extreme betas and bias ratio. In comparison, the Markowitz technique (and its more sophisticated "fat tails"-based optimizer) naively assumes that a fund's risk only derives from its returns stream.

This is proven by retrospectively-comparing the allocation-per-strategy between the 2 techniques: FOFiX allocated more to strategies that tend to exhibit their risks (macro and equity hedge), while Markowitz tended to overweight strategies that "hide their risks" (event driven and relative value):

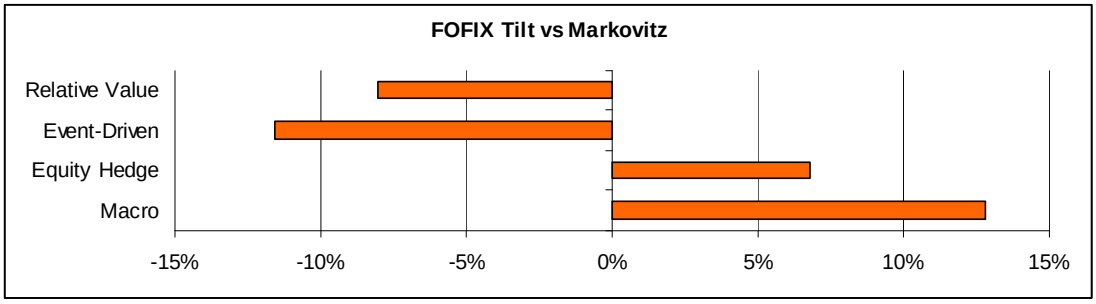


Figure 3 : Comparison between FOFiX and Markowitz techniques on average allocation per strategy. Bars on the right side clearly show that FOFiX over-weighted, when Markowitz under-weighted.

... and focus on "tail risk" rather than "business-as-usual" risk

Another reason why FOFiX strongly over-performs, is that it obviates "business as usual" risk constraints. Because tail risk is kept under control, one can afford to employ higher leverage than with the other strategies. As a result, FOFiX over-performs Markowitz, even during "business-as-usual" periods, *this in spite of the fact that its Sharpe ratio is lower:*

From Jan-06 To Jul-07	Capital Allocation	Passive Risk Allocation	Markowitz	FOFiX
Average Annual Returns	11.0%	8.9%	15.2%	15.9%
Annualized Volatility	3.7%	1.8%	3.1%	5.5%
Worst Month	-1.4%	-0.6%	-1.4%	-3.3%

III. Conclusion

Our previous white paper demonstrated that extreme risk profiling was the only reliable way to anticipate extreme risks over time. This study provides an explicit confirmation that an efficient risk management tool can bring considerable value to the portfolio construction process. To demonstrate this, we used a purely quantitative approach to avoid any bias stemming from ex-post knowledge of funds performance.

In real life, this strong value can be extracted through a combination of: 1) a semi-qualitative process of selection and portfolio construction with, 2) a quantitative assessment of the risk. The risk control brings considerable value, **as long as it is fully integrated into the investment process**, offering a precious feedback loop in order to:

1. Raise alerts on managers exhibiting abnormal patterns (hidden risks);
2. Quantify the contribution of each manager to portfolio diversification, both for normal risks (typically, marginal VaR) and extreme risks (extreme betas), which in turn helps build portfolios which are actually consistent with qualitative views on managers – high risk contributions will associate with very good qualitative ratings;
3. Check if the portfolio risk profile (i.e. exposure to market events, including extreme events) is consistent with the tactical view and/or the client mandate – and find solutions to correct this profile, if the latter is not in line with expectations.

Appendix 1:
Detailed results of the study

I. Study Parameters

The initial sample was comprised of 738 hedge funds – which reported their performances to the HFR database, at least since March 2000 up to December 2008. We then selected 3 random short lists from this group of funds, resulting in the following samples:

	Sample 1		Sample 2		Sample 3		Initial Sample	
	#Funds	%	#Funds	%	#Funds	%	#Funds	%
Equity Hedge	15	31%	21	49%	23	41%	333	45%
Event-Driven	6	13%	6	14%	7	13%	111	15%
Macro	18	38%	8	19%	16	29%	182	25%
Relative Value	9	19%	8	19%	10	18%	112	15%
Grand Total	48	100%	43	100%	56	100%	738	100%

We then applied 4 techniques of portfolio constructions on each of these samples:

1. **Capital Allocation**: with this technique, we simply allocate the same amount of money to each manager. We then adjust leverage in order to obtain a monthly volatility of less than 1.3% of the volatility required to keep the worst month below 3% with a 99% confidence interval (assuming a "Gaussian" distribution). The volatility was estimated using the past 3 years ex-post volatility;
2. **Risk Allocation**: we allocate 3% of the risk budget equally to all funds, conservatively assuming that the funds were 100% correlated. Technically, this entails converting the % risk budget into $ risk, then allocating it equally to each fund. The $ allocation for a fund is ten simply derived by dividing the risk budget by its %99 Monte-Carlo Value at risk, as calculated by FOFiX;
3. **Markowitz**: we simply used the Markowitz optimizer, with a targeted monthly volatility of 1.3%, and expected excess returns equal to the past 3 years average returns. The volatility was estimated as in Capital Allocation method (see above);
4. **FOFiX**: Here, we combine a classical risk allocation process with a ***tail risk budget of 3%***, set on the extreme risk as measured by our nonlinear factor models, and using the techniques described in detail in Appendix 2.

For all these techniques, we limited the allocation on each fund to between 0% and 5%. Cash/Leverage was used as an adjusting variable, so as to match both "Total Capital-to-Allocate" and the Risk Budget.

The 3 random samples multiplied by 4 techniques were rebalanced, using the following schedule:

- Mid September 2005: portfolio allocations were calculated based on performance available up to August 2005 – to actually be implemented on January 1st, 2006, and run up to the end of April 2006;
- Mid January 2006: new allocations were calculated based on performances available up to the end of 2005 – to actually be implemented at the end of April 2006, and run up to end of April 2007;
- The same process was repeated for 2007 and 2008.

II. Results

The study analyzes twelve funds, and their track records over a defined period. (For details, consult the table at the end of this appendix. The resulting portfolios have the following characteristics:

		Capital Allocation	Risk Allocation	Markowitz	FOFiX
Allocation per Strategy	Equity Hedge	41%	34%	31%	38%
	Event-Driven	13%	13%	22%	11%
	Macro	27%	19%	12%	25%
	Relative Value	19%	34%	34%	26%
Average Leverage		64%	61%	111%	118%
Operational Risk (*)		2.1%	3.2%	3.8%	3.5%
Measured by the formula (1+%Allocation Variance)*Average Allocation/Total Allocation					

The twelve resulting track records exhibited the following characteristics, over the period under consideration (before management and performance fees):

From Jan-06 To Dec-08	*Short Lists Techniques*	1	2	3	Mean	Sigma
% of Month with loss exceeding 3%	Capital Allocation	0.0%	2.8%	0.0%	0.9%	1.6%
	Passive Risk Allocation	0.0%	0.0%	0.0%	0.0%	0.0%
	Markowitz	5.6%	8.3%	5.6%	6.5%	1.6%
	FOFiX	2.8%	0.0%	0.0%	0.9%	1.6%
Average Annual Return	Capital Allocation	6.9%	3.9%	5.4%	5.4%	1.5%
	Passive Risk Allocation	5.8%	4.3%	4.8%	5.0%	0.8%
	Markowitz	3.9%	2.9%	5.7%	4.2%	1.4%
	FOFiX	9.0%	7.1%	10.1%	8.8%	1.5%
Annualized Volatility	Capital Allocation	5.6%	4.6%	4.4%	4.9%	0.7%
	Passive Risk Allocation	3.6%	2.6%	2.6%	2.9%	0.6%
	Markowitz	6.5%	6.6%	6.1%	6.4%	0.3%
	FOFiX	6.0%	5.5%	4.8%	5.4%	0.6%
Sharpe Ratio (Risk Free Rate = 4%)	Capital Allocation	0.51	-0.02	0.32	0.27	0.27
	Passive Risk Allocation	0.50	0.12	0.31	0.31	0.19
	Markowitz	-0.02	-0.16	0.28	0.03	0.22
	FOFiX	0.83	0.57	1.29	0.89	0.37
Worst Month	Capital Allocation	-2.2%	-3.0%	-2.4%	-2.5%	0.4%
	Passive Risk Allocation	-1.6%	-1.6%	-1.4%	-1.5%	0.1%
	Markowitz	-4.3%	-6.2%	-5.2%	-5.2%	1.0%
	FOFiX	-3.3%	-2.9%	-2.1%	-2.7%	0.6%

Analyzing the performances over the period prior to the crisis, i.e. up to July 2007, one obtains results as follows:

From Jan-06 To Jul-07	*Short Lists Techniques*	1	2	3	Mean	Sigma
% of Months with Loss Exceeding 3%	Capital Allocation	0.0%	0.0%	0.0%	0.0%	0.0%
	Passive Risk Allocation	0.0%	0.0%	0.0%	0.0%	0.0%
	Markowitz	0.0%	0.0%	0.0%	0.0%	0.0%
	FOFiX	5.3%	0.0%	0.0%	1.8%	3.0%
Average Annual Return	Capital Allocation	12.4%	10.4%	10.2%	11.0%	1.2%
	Passive Risk Allocation	9.4%	8.6%	8.8%	8.9%	0.4%
	Markowitz	14.3%	15.4%	16.0%	15.2%	0.9%
	FOFiX	16.4%	15.3%	16.0%	15.9%	0.6%
Annualized Volatility	Capital Allocation	4.7%	3.3%	3.0%	3.7%	0.9%
	Passive Risk Allocation	2.2%	1.7%	1.6%	1.8%	0.3%
	Markowitz	3.4%	2.9%	2.9%	3.1%	0.3%
	FOFiX	7.2%	4.8%	4.4%	5.5%	1.5%
Sharpe Ratio (Risk Free Rate = 4%)	Capital Allocation	1.80	1.95	2.04	1.93	0.12
	Passive Risk Allocation	2.47	2.74	3.04	2.75	0.28
	Markowitz	2.99	3.94	4.09	3.68	0.60
	FOFiX	1.72	2.37	2.69	2.26	0.50
Worst Month	Capital Allocation	-1.4%	-0.8%	-0.6%	-0.9%	0.4%
	Passive Risk Allocation	-0.6%	-0.1%	0.0%	-0.2%	0.3%
	Markowitz	-1.4%	-0.1%	-0.5%	-0.6%	0.7%
	FOFiX	-3.3%	-0.7%	-0.1%	-1.4%	1.7%

The comprehensive track records for the 12 funds are as follows:

	Capital Allocation SL 1	Capital Allocation SL 2	Capital Allocation SL 3	Risk Allocation SL 1	Risk Allocation SL 2	Risk Allocation SL 3	FOFiX SL 1	FOFiX SL 2	FOFiX SL 3	Markowitz SL 1	Markowitz SL 2	Markowitz SL 3
Jan-06	4.22%	2.81%	2.71%	1.52%	1.77%	1.76%	4.78%	3.89%	4.58%	2.56%	3.13%	2.68%
Feb-06	0.02%	0.10%	0.08%	0.27%	0.36%	0.36%	-0.46%	0.37%	0.21%	0.46%	0.67%	0.56%
Mar-06	2.21%	2.20%	1.71%	1.12%	1.50%	1.08%	3.38%	3.39%	2.82%	1.52%	2.14%	1.78%
Apr-06	3.38%	1.62%	2.04%	1.29%	1.05%	1.23%	4.23%	2.79%	3.72%	1.79%	1.86%	1.23%
May-06	-1.40%	-0.79%	-0.62%	-0.58%	-0.09%	-0.04%	-3.30%	-0.75%	-0.07%	-1.37%	0.02%	0.10%
Jun-06	-0.17%	-0.16%	0.08%	-0.04%	0.19%	0.39%	-1.14%	-0.04%	0.76%	-0.43%	0.27%	1.37%
Jul-06	-0.15%	-0.64%	-0.17%	0.10%	0.00%	0.21%	-0.16%	-0.50%	0.05%	0.48%	0.16%	0.22%
Aug-06	0.39%	0.83%	0.45%	0.43%	0.68%	0.44%	0.19%	1.21%	0.28%	0.65%	1.05%	0.50%
Sep-06	-0.27%	0.46%	0.17%	0.06%	0.40%	0.24%	-1.31%	-0.17%	0.11%	-0.19%	-0.06%	-0.45%
Oct-06	1.18%	1.35%	0.94%	0.71%	0.98%	0.75%	2.23%	1.87%	1.20%	1.42%	1.86%	1.62%
Nov-06	1.50%	1.12%	1.26%	1.00%	0.78%	0.98%	2.85%	1.34%	1.62%	1.76%	1.51%	2.12%
Dec-06	1.17%	1.44%	0.91%	0.92%	0.98%	0.75%	2.37%	2.41%	0.36%	1.65%	1.98%	0.81%
Jan-07	0.68%	0.97%	0.87%	0.91%	0.79%	0.77%	1.76%	1.04%	0.71%	1.82%	1.69%	1.18%
Feb-07	0.09%	-0.07%	0.20%	0.56%	0.29%	0.49%	0.61%	0.69%	0.56%	1.60%	1.05%	0.87%
Mar-07	0.42%	0.26%	0.34%	0.52%	0.49%	0.48%	1.09%	0.85%	0.58%	1.18%	1.59%	1.53%
Apr-07	1.76%	1.37%	1.49%	1.35%	0.94%	1.00%	4.05%	0.89%	1.07%	2.50%	1.40%	1.88%
May-07	2.00%	1.57%	1.96%	1.85%	1.02%	1.42%	1.06%	-0.63%	2.21%	1.27%	0.78%	2.82%
Jun-07	1.40%	1.02%	1.08%	1.54%	0.60%	0.76%	0.90%	1.09%	1.63%	1.59%	0.56%	1.38%
Jul-07	0.21%	0.24%	-0.02%	0.68%	0.31%	0.34%	1.11%	2.96%	1.19%	1.00%	1.11%	1.45%
Aug-07	-1.16%	-1.00%	-1.30%	-0.53%	-0.45%	-0.49%	-0.26%	0.59%	-0.01%	-1.29%	-0.38%	-0.10%
Sep-07	3.15%	1.80%	2.19%	2.68%	1.05%	1.35%	1.78%	1.91%	2.04%	2.36%	1.31%	2.38%
Oct-07	2.75%	1.83%	2.62%	2.38%	1.14%	1.64%	1.80%	0.35%	2.09%	2.80%	1.13%	3.21%
Nov-07	-1.41%	-0.37%	-0.92%	-1.12%	-0.08%	-0.49%	-0.52%	2.76%	0.11%	-1.28%	-0.33%	-0.72%
Dec-07	0.98%	0.58%	0.47%	0.26%	0.36%	0.27%	-0.28%	0.67%	0.45%	0.29%	0.10%	0.35%
Jan-08	-0.93%	-1.12%	-1.19%	-0.47%	-0.42%	-0.74%	-0.06%	0.09%	-0.16%	-2.13%	-1.29%	-2.39%
Feb-08	2.95%	1.35%	2.23%	2.23%	0.70%	1.04%	1.76%	0.76%	2.33%	2.06%	0.67%	1.25%
Mar-08	-2.02%	-0.99%	-0.81%	-1.63%	-0.57%	-0.38%	-0.89%	-0.01%	-0.50%	-2.25%	-0.56%	-1.19%
Apr-08	1.32%	1.02%	0.96%	0.98%	0.63%	0.92%	0.42%	-0.60%	0.66%	1.79%	0.23%	1.67%
May-08	1.74%	1.41%	1.56%	0.96%	0.82%	0.85%	1.20%	1.04%	2.06%	2.38%	2.47%	1.61%
Jun-08	0.58%	-0.39%	0.30%	0.25%	-0.15%	0.03%	-0.15%	-0.43%	0.54%	-0.49%	-0.04%	-0.64%
Jul-08	-1.76%	-2.25%	-1.87%	-0.61%	-0.68%	-0.43%	-1.52%	-2.86%	-1.56%	-2.51%	-3.00%	-1.54%
Aug-08	-1.14%	-0.45%	-0.86%	-0.29%	0.05%	-0.18%	-0.66%	-0.52%	-1.24%	-1.36%	-0.81%	-1.51%
Sep-08	-2.16%	-3.01%	-2.45%	-1.27%	-1.57%	-1.36%	-0.59%	-2.56%	-2.08%	-4.01%	-4.82%	-3.26%
Oct-08	-1.58%	-2.44%	-0.71%	-1.17%	-1.51%	-1.19%	-0.31%	-2.77%	1.56%	-4.32%	-6.24%	-5.18%
Nov-08	-0.48%	-0.91%	-0.45%	-0.27%	-0.26%	-0.48%	-0.32%	-1.30%	-0.78%	-1.76%	-2.58%	-0.86%
Dec-08	0.50%	0.80%	0.60%	0.36%	0.53%	0.31%	0.35%	0.87%	-0.05%	-0.18%	0.09%	-0.13%

Appendix II:
FOFiX systematic portfolio construction technique, as tested in the study

The input of the technique is:

- A Short List SL of funds (typically between 50 and 200), from which we intend to derive a portfolio,
- An approved list AL of funds that can be used potentially to fine-tune a risk profile
- A bias ratio threshold BR (in our study we used 3 as a value. In real life this should be differentiated according to the strategy and the liquidity of the asset – see bias ratio white paper)
- A maximum tail risk *MaXBeta*, which is the maximum monthly drawdown that one is ready to accept with a 99% confidence
- Constraints on allocation sizes (in our study, min = no negative position, max = 5%).

The output is a portfolio P, with extreme betas -- lower than *MaXBetas* and Betas++ higher than *–MaxBetas*. The parameter involved in the technique is a '*Usual Portfolio* construction technique' U, which takes the short list SL as an input, and delivers a vector of allocations P as an output (complying with constraints on allocation sizes). This technique U is your usual allocation technique. It can be qualitative, quantitative, bottom up, top down etc… In our study, we used a simple pure quantitative allocation rule for U: an equal risk allocation assuming all funds were uncorrelated, such that:

Weight(i) = Total risk Budget/ RtVaR(99,Fund (i))/sqrt(Number of Funds)

The "uncorrelated" hypothesis may sound optimistic, but in reality the correlation aspect in this technique is managed through the Betas.

To prepare the exercise as if one was positioned at a certain Simulation Date, one requires:

- Upload all initial short list funds track records, with an end date prior to the Simulation Date (important if running an out-of-sample test);
- Set the Riskdata date at the Simulation Date;
- Create fund risk profiles according to workflow, with end-dates set prior to dates of simulation.

Portfolio construction then follows a sequence of 3 steps:

1. Remove from the Short List all funds having the Bias Ratio above BR. The rational is the following: one cannot base a quantitative process on performance data which is not marked to market. By construction,

funds with a high Bias Ratio exhibit compelling risk / return patterns, which generally lead to bad surprises – see our white paper on the Bias Ratio. Of course, one could maintain these in the portfolio, if serious qualitative due diligence could lead to a rational explanation for the level of the Bias Ratio. This stage can be easily completed using the screening tool to display the Bias Ratio.

2. Iteratively build a portfolio, using technique U and removing all funds which have both: 1) an *extreme risk profile* close to the one of the portfolio (which yields little in term of diversification) and, 2) a null or negative regression alpha.

   This stage is completed running the following iteration:

   a) Apply the technique U on the Short List SL;

   b) Upload both the resulting portfolio and its proforma track record into FOFiX. Copy the portfolio risk profile onto the proforma track record;

   c) Screen the Short list, with the portfolio as target, Xsensi & Factors as distance. Remove any fund with RegAlpha <=0 and Sensi rating = 1, B or C, and XBetas Rating = A or B. Run this on ALL factors first, then, when you find no funds matching the criteria, one can use Top5, then Top3 up to Top1;

   d) Reiterate from a/, as long as there are still funds matching c/ criteria or the number of funds fall below your operational rules.

3. Reduce Xbetas that exceed the limit MaXBetas, by increasing the proportion of cash and / or top diversifiers. In order to do this, you can run the following iteration:

   a) Sort factors by decreasing XSesni and select the first one which Beta++ or Beta—exceed risk limit. Drill down to identify:

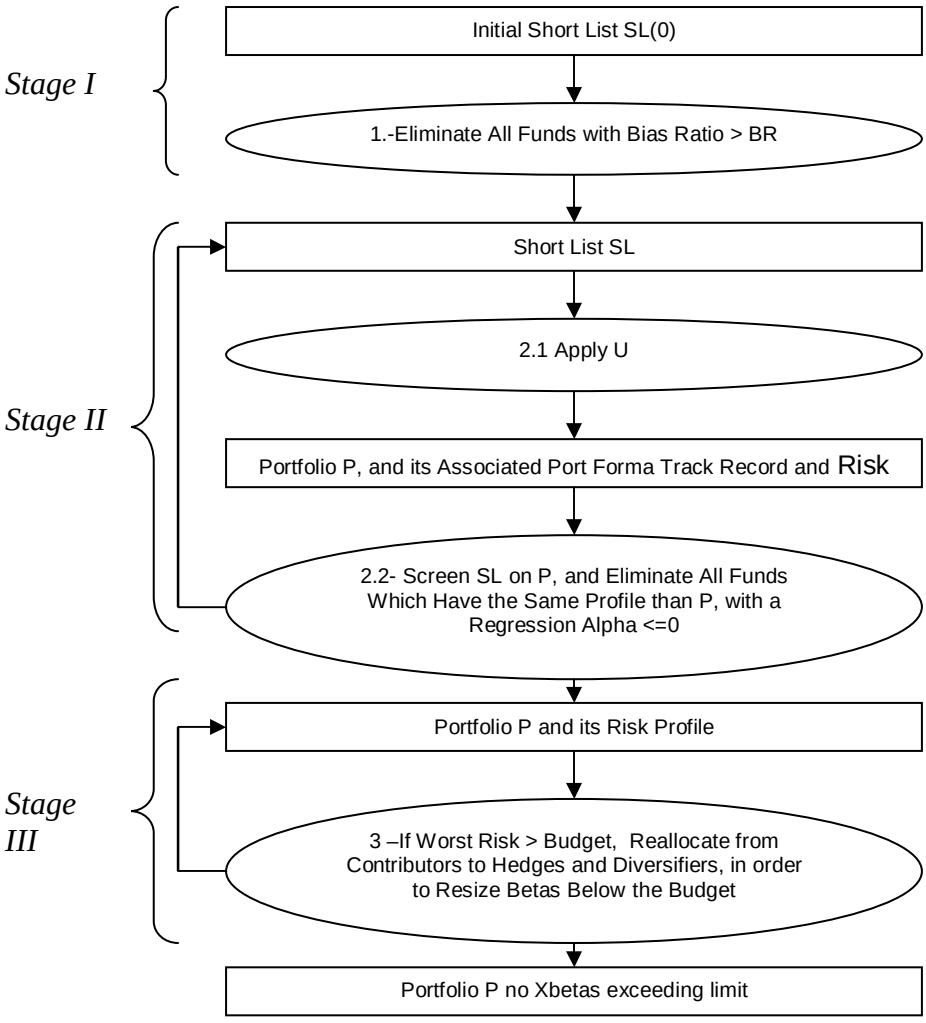
      - *Hedges*, i.e. fund having opposite Betas vs. the FoF one. They can be spotted going into the drill-down box, under the "exposure to" item;
      - *Contributors*, i.e. funds contributing to increase the FoF Beta. These can be spotted by going into the drill-down box, under the "incremental contribution" item;
      - *Diversifiers*, i.e. funds having no exposure to the factors and mitigating the FoF betas. They can be spotted going into the drill-down box, under the "incremental contribution" item.

   b) Reallocate from Cash to Hedges, so as to reduce the Beta up to its limit or Sensi below the minimum confidence level.[5] When the Cash limit is reached, reallocate from Contributors to

[5] To calculate the amount which must be reallocated, one needs to use the relationship: □□P = □H□H + □C□C, where □□P is the change in portfolio Betas obtained by a change of □H in the weight of the hedges and of C on the contributors, □H being the beta of the hedges, the □C of the contributors. Hedges and Contributors can be weighted prorate their sensitivities.

Hedges. When allocation limits on Hedges are reached, reallocate from Contributors to Cash. When the Cash limit is reached, reallocate from Contributors to Diversifiers.

c) Reiterate on a/, as long as there are Betas (with Sensi above confidence level) exceeding the budget.



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