The necessity to correct hedge fund returns: empirical evidence and correction method

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Abstract

We study two principal mechanisms suggested in the literature to correct the serial correlation in hedge fund returns and the impact of this correction on financial characteristics of their returns as well as on their risk level and on their performances. The methods of Geltner (1993), its extension by Okunev & White (2003) and that of Getmansky, Lo & Makarov (2004) are applied on a sample of 54 hedge fund indexes. The results show that the unsmoothing leaves the mean unchanged but increases significantly the risk level of hedge funds, whether the risk is measured in terms of the return standard-deviation or the modified VaR. Funds' absolute performances, measured by traditional Sharpe ratio and Omega index, decline considerably. By contrast, funds' rankings after the unsmoothing unexpectedly change slightly. However, some notable modifications in ranks of several funds are observed. The necessary transparency of the management practice requires that such a correction must be systematically done.

Keywords: hedge funds, smoothed returns, performance evaluation, Sharpe ratio, Omega index.

JEL Classification : G2, G11, G15

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1 Introduction

The extraordinary performances obtained by hedge funds during the last two decades, especially during the long bullish period of the 90s, have made known to the general public this new kind of funds. Before, they were open only to wealthy individuals; now, many institutional investors tend to invest into them and one may expect very soon the coming of "ordinary" investors.

The hedge funds are attractive because they seem to be able to have good performances regardless of the general market conditions; in other words, they are uncorrelated with the traditional assets. Thus, they increase the returns and/or reduce the risk, hence increasing the diversification effects of portfolios basically constituted with traditional assets. Nevertheless, this characteristic is measured in the framework that returns follow a normal distribution, independantly and identically distributed. Yet, many empirical studies tend to prove that the hedge fund returns are very far from this assumption, which questions the relevance of the meaning of these measurements. One of the most important issues is raised by Asness, Krail & Liew (2001), Brooks & Kat (2002), Kat & Lu (2002), Okunev & White (2003), Getmansky, Lo & Makarov (2004): the existence of a large serial correlation in hedge fund returns, which basically implies that the risk of the hedge funds is underestimated.

As the risk and performance measurement of hedge funds is crucial, this research deals with this issue in presence of a serial correlation in their returns. Moreover, we wish to draw the attention of fund managers on this problem and on the possibility to correct it.

In this perspective, this paper is organized as follows. First, we try to explain why the serial correlation does exist (section 2). Then we empirically show its existence (section 3). We present in section 4 two corrective methods which are applied on a sample of hedge fund indexes in section 5. Section 6 compares statistical characteristics of "smoothed" and "unsmoothed" returns. Section 7 analyzes the consequences on the performance measurement. We conclude in section 8.

2 Ambiguous nature of the serial correlation in hedge fund returns: natural or intentional?

The serial correlation in hedge fund returns seems to have two causes; one "natural" reason due to the illiquidity of the assets held by the hedge fund portfolios and one "intentional" reason due to the fund manager's compensation scheme.

2.1 Illiquidity of assets

One of the hedge funds' specificities is to hold either illiquid assets or assets whose pricing is difficult to assess, like non-quoted assets in private equity, stocks of "distressed" companies, some stocks quoted in emerging markets, real estate, etc. According to a 2004's study by the Alternative Investment Management Association (AIMA), 20% of these assets held by hedge funds are difficult to price! According to Waters (2006) and Kentouris (2005), these percentage can reach 50%, even 100% in the case of some strategies like Fixed Income Arbitrage, Convertible Arbitrage, Distressed Debts, Emerging Markets and Mortgage-Backed Securities. According to these two authors, the hedge funds' managers believe that this lack of information on these assets creates opportunities for profits. Since a market price is not available or available irregularly, subjectivity interferes for the valuation of the net asset values (NAV) of the fund, subjectivity either from the manager or from the specialized brokers who can be asked for this task[1]. In such cases, the fund managers do not deliberately try to smooth the NAV, this "subjective" pricing induces a serial correlation in their returns.

2.2 Influence of the managers' compensation scheme

Hedge funds have a very different compensation scheme of their managers than the traditional funds. The manager receives "incentive fees" which are generally 20% of the excess returns relative to a benchmark; these incentive fees are subjected to the "high-water mark", the highest net asset value obtained. It means that the manager has first to recover his losses relatively to this highest value before receiving the incentive fees. During the recovery period, he receives only "management fees"[2]. Third implicit feature of the compensation scheme: the incentive fees percentage is computed on the net asset managed; in other words, its amount is proportional to the fund's size. It is obvious that there is a huge temptation for some unscrupulous managers to use their illiquid and their "subjectively priced" assets to manipulate the computation of their NAV and, then, their returns[3]. Even if one may believe that the majority of managers do not "manipulate" the NAV, the smoothing of returns is helped by the lack of regulation, the lack of legal obligations to publish NAV, the detailed content of portfolios and to be audited.

To sum up, the serial correlation of hedge fund returns is partially "natural" (unintentional) due to the pricing problem on the non-quoted assets held, and partially "intentional" due to the manager's personal motivation to optimize his returns over several periods. But this above "smooth" assertion is made much more brutal by Andrew Lo – who is finance

[1] It should be stressed that specialized brokers do not give the same estimate. For instance, according to Lhabitant (2004), the valuation in december 2000 of Collateralized Mortgage Obligations given by five brokers had a range of 6 to 44%!

[2] Some contracts include a "hurdle rate" which is the minimum performance to be obtained in order to receive incentive fees.

[3] This phenomenon of accounting manipulation has already caused the bankruptcy of 3 hedge funds, Manhattan, Ballybunion and Volter (Ineichen 2000).

professor at the MIT but in the meantime, manager of a hedge fund – who says "Most hedge fund managers are good, honourable people. But there are probably some engaged in unsavoury practices."[4].

3 Evidence of serial correlation in hedge fund returns

3.1 American literature review

Several studies show the evidence of serial correlation in hedge funds' returns — Asness et al. (2001), Brooks & Kat (2002), Kat & Lu (2002), Okunev & White (2003) et Getmansky, Lo & Makarov (2004).

Examing 10 CSFB/Tremont hedge fund indexes, Asness et al. (2001) found that regressing hedge fund returns on the actual return and three lagged returns of the market portfolio results in a beta (the true beta is the sum of the four estimated betas) which is much higher than the beta obtained without market's lagged returns. Besides, the estimated alpha in the latter case is positive while in the former case, it becomes non significantly negative. This finding implies that neglecting the smoothing chacracteristic leads to an underestimation of market risk exposed by hedge funds and thus to an overestimation of the managers' ability. Their analysis according to market conditions, bull or bear markets, shows that hedge fund managers are more concerned to smooth their poor returns than their good ones, which confirmes the presence of the managed price practice.

Brooks & Kat (2002) examined the statistical characteristics of 48 hedge fund indexes and observed a highly positive serial correlation of order 1 in almost all series. As a result of this, the risk measured by the standard deviation of returns is downwardly biased, and the Sharpe ratio is thus downwardly biased. This result is then corroborated by Kat & Lu (2002) and Okunev & White (2003).

In an empirical study conducted on a sample of 12 hedge funds, Lo (2002) noticed that the serial correlation in monthly hedge fund returns can overestimate the Sharpe ratio by up to 65%, which modifies dramatically fund rankings based on this performance measure.

Later, Getmansky, Lo & Makarov (2004) demonstrated mathematically that smoothing returns does not affect the mean return but does decrease the variance, thus decreases the beta and increases the Sharpe ratio. By means of a theoritical model, the authors showed that a serial correlation of orders 1 and 2 (67% of order 1, 33% of order 2) in monthly returns causes a decrease of 67% in beta and an increase of 73% of the Sharpe ratio.

In short, the serial correlation detected in hedge fund returns casts doubt on the robustness of previous findings on hedge funds' low risk (small standard deviations), low correlation with traditional assets (small betas) and thus ideal portfolio diversifiers.

[4]cf. "Is your hedge fund manager too smooth?", *Institutional Investor*, November 2002, N°11, p.9.

3.2 Empirical evidence

3.2.1 Data

We use the hedge fund indexes produced by three databases: 13 indexes from CSFB/Tremont (CSFB), 24 indexes from Hedge Fund Research (HFR) and 17 indexes from Greenwich-Van (GV), thus a total sample of 54 "hedge funds". These indexes have two advantages. First, they are the most used in the academic studies on hedge funds, which enables to compare our results with the previous ones. Second, they are computed on a rather long time period, which ensures that the computations are rather robust. Each index has 146 monthly returns over the period from April 1994 to May 2006.

For comparison purposes, 5 indexes representing the traditional asset classes are selected: S&P 500, Russell 2000, Wilshire Small Cap 1750, Lehman US Aggregate Bond and Lehman High Yield. Except for the HFR and GV indexes, which come from their websites, the others are obtained from Datastream.

3.2.2 Evidence of serial correlation in hedge fund returns

Table 1 presents the serial correlation coefficients of these indexes. The empirical evidence is impressive: 40 out of 54 indexes have serious serial correlation of order 1 (74% of the sample) and 6 even have positive serial correlation of order 2. The statistical significance of the serial correlation is extremely strong since 75% of the coefficients (30 out of 40 autocorrelated ones) are significant at 1% level.

Very revealing are five of the six indexes which have a serial correlation of orders 1 and 2 - which can be said to be "over-smoothed". The three Convertible Arbitrage indexes and the HFR Relative Value Arbitrage suggest that the serial correlation is "natural" and due to the management technique used. Also there is the HFR Fixed Income High Yield: it holds junk bonds non-quoted, which proves the problem arising from the pricing difficulties. On the other hand, hedge funds holding traditional assets do not display any autocorrelation. These are the strategies Short Selling (4 cases), Futures (2 cases), Macro (3 cases), GV Agressive Growth, GV Income, etc.

Moreover, all the indexes of traditional assets used as benchmarks, including the Lehman High Yield index, which often holds illiquid assets, have also no serial correlation. Their coefficients are generally negative and small in absolute value; all are statistically non significant. This result confirms the hypothesis that serial correlation is a characteristic of some and not all hedge fund strategies.

This finding is in line with the results obtained by Brooks & Kat (2002), Kat & Lu (2002) et Getmansky, Lo & Makarov (2004). It shows that these returns must be "unsmoothed" in order to measure their "true" risks and their "true" benefits.

Table 1: Autocorrelation coefficients of the original return series (in %)

Indexes	ρ_1		ρ_2		Indexes	ρ_1		ρ_2	
CSFB					**HFR (cont)**				
Convertible Arbitrage	56.0	***	38.0	**	*Macro*	7.0		-2.0	
Dedicated Short Bias	9.0		-5.0		*Market Timing*	-0.2		8.0	
Emerging Markets	29.0	***	2.0		**Merger Arbitrage**	25.1	***	16.0	
Equity Market Neutral (EMN)	29.0	***	16.0		Relative Value Arbitrage	31.0	***	21.0	**
Event Driven	33.0	***	14.0		**Sector**	16.1	*	4.0	
Event Driven Distressed	28.0	***	13.0		*Short Selling*	8.0		-10.0	
Event Driven Multi-Strategy	32.0	***	15.0		**GV**				
Event Driven Risk Arbitrage	29.0	***	-2.0		Equity Market Neutral	22.0	***	9.0	
Fixed Income Arbitrage	38.0	***	6.0		Event-Driven	27.9	***	9.1	
Global Macro	1.0		3.0		Distressed Securities	30.1	***	9.1	
Long Short Equity	14.0	*	4.0		Special Situations	25.3	***	10.1	
Managed Futures	4.0		-10.0		Market Neutral Arbitrage	42.3	***	16.2	
Multi Strategies	1.0		5.0		Convertible Arbitrage	55.4	***	26.9	**
HFR					Fixed Income Arbitrage	36.6	***	17.0	
Convertible Arbitrage	52.1	***	23.0	**	*Aggressive Growth*	-0.3		5.4	
Distressed Security	42.5	***	13.0		Opportunistic	16.0	*	9.8	
Emerging Markets (total)	30.7	***	7.0		*Short Selling*	12.3		-9.8	
Emerging Markets (Asia)	36.5	***	21.0	**	Value	17.0	**	-3.0	
Equity Hedge	17.5	**	7.0		*Futures*	4.3		-13.5	
Equity Market Neutral (EMN)	7.3		10.0		*Macro*	3.9		-3.5	
EMN Statistical Arbitrage	20.4	**	15.0		Market Timing	13.9	*	8.9	
Equity Non Hedge	15.2	*	-9.0		Emerging Markets	19.7	**	9.0	
Event Driven	26.6	***	4.0		*Income*	-0.5		4.2	
Fixed Income (total)	29.6	***	14.0		Multi-Strategy	18.6	**	0.3	
Fixed Income Arbitrage	34.1	***	2.0		***Mean*$^{\psi}$**	**28.7**		**25.0**	
Fixed Income High Yield	32.7	***	20.0	**					
FoF Conservative	36.1	***	17.0		**MARKETS**				
FoF Diversified	33.3	***	6.0		S&P 500	-4.0		0.9	
FoF Market Defensive	7.0		3.0		Lehman US Aggregate	-0.1		-0.1	
FoF Strategic	28.3	***	10.0		Lehman High Yield	13.0		-6.0	
FoF Composite	31.3	***	9.0		Russell 2000	3.0		-4.0	
Fund Weighted Composite	20.7	***	2.0		Wilshire Small Cap 1750	0.0		-2.0	

The serial correlation of orders 1 to 10 have been computed. The index portfolios printed in italic are portfolios without serial correlation. The 4 portfolios in bold are those which also have a serial correlation of order 5 or of order 6. It should be noted that CSFB Global Macro and HFR Equity Market Neutral have a serial correlation respectively of order 5 or of order 6.) * arithmetical average of the 40 autocorrelated indexes.

4 The unsmoothing of hedge fund returns

There are only two academic studies which suggest a practical solution to this problem of serial correlation[5]. These two methods for correcting the hedge fund returns are briefly presented in the following section.

4.1 Method of Geltner (1993) and its extension by Okunev & White (2003)

Brooks & Kat (2002) and Okunev & White (2003) suggest to unsmooth the smoothed returns in order to obtain a new corrected serie. For this purpose, they use a method developped by Geltner (1993) to deal with the real estate markets. According to this method, the price of the period t is often determined on the basis of the price of the previous period $t-1$

[5]Two authors, Lo (2002) and Getmansky and al. (2004) suggest a way for calculating the Sharpe ratio when the returns are not time independent (not idd). These two proposals are very simple to use but they only correct the consequence of the serial correlation on the performance measurement. We prefer to deal with how to suppress that phenomenon.

because of the illiquidity of real estate assets. Hence, the smoothing structure (intentional or not) of returns of a given period is formulated as follows: the observed (smoothed) return R_t^o in t is a weighted average of its "true" return $R_{1,t}^c$ in t (the inferior index 1 indicates that returns are corrected for the first time) and the previous observed (smoothed) return R_{t-1}^o:

$$R_t^o = (1 - c_1)R_{1,t}^c + c_1 R_{t-1}^o \tag{1}$$

with c_1 the weighted coefficient. The "true" return $R_{1,t}^c$ in t is thus equal to:

$$R_{1,t}^c = \frac{R_t^o - c_1 R_{t-1}^o}{(1 - c_1)} \tag{2}$$

In fact, c_1 is the root (smaller than 1) of a second-degree equation and given that the equation (1) is an auto-regressive of order 1 [$AR(1)$], c_1 is simply equal to the autocorrelation coefficient of the first order:

$$c_1 = \rho_1^o \tag{3}$$

Consequently, each observed return is corrected following the equation (2), in which c_1 is replaced by ρ_1^o:

$$R_{1,t}^c = \frac{R_t^o - \rho_1^o R_{t-1}^o}{(1 - \rho_1^o)} \tag{4}$$

Later, Okunev & White (2003) generalized this method by using the same reasoning as that of Geltner (1993) to correct serial correlations of higher orders than 1.

4.2 Method of Getmansky, Lo & Makarov (2004)

The method of Getmansky, Lo & Makarov (2004) (henceforth GLM) assumes that the observed return in period t (R_t^o) is a weighted average of the "true" returns [R^c] over the most recent $k+1$ periods, including the current period:

$$R_t^o = \theta_0 R_t^c + \theta_1 R_{t-1}^c + \ldots + \theta_k R_{t-k}^c \tag{5}$$

with two conditions:

$$\theta_j \in [0,1]\ , j = 0, \ldots, k \tag{6}$$

$$1 = \theta_0 + \theta_1 + \ldots + \theta_k \tag{7}$$

After some intermediate developments of the equation (5), the θ can be estimated by the maximum likelihood technique. The smoothing index (measuring the smoothing level) is equal to the sum of the squared θ_j, soit $\xi = \sum_j^k \hat{\theta}_j^2$ (by construction $0 \leq \xi \leq 1$). *A small value of ξ implies a high smoothing level, $\xi = 1$ indicates no smoothing.*

Once the θ_i are estimated, the "true" return in t is obtained by "inverting" the equation (5):

$$R_t^c = \frac{R_t^o - \hat{\theta}_1 R_{t-1}^c - \ldots - \hat{\theta}_k R_{t-k}^c}{\hat{\theta}_0} \tag{8}$$

A recurring application of the formula (8) on the observed returns provides a serie of corrected returns which is free of serial correlation.

In this method, the subtlety relies on the choice of the parameter k. According to GLM, the non-convergence of the estimation procedure (maximum likelihood) and/or the (statistically significiant) negativity of the $\hat{\theta}$ can be viewed as a first warning of a bad specification of the smoothing profile (equation (5)). In this case, it is necessary to test another value of k[6]. In addition, GLM mathematically demonstrate that (i) the mean return of the unsmoothed returns stays the same as that of the observed returns ($\mu_c = \mu_o$), (ii) the variance of the observed returns is ξ times smaller than that of the unsmoothed ones ($\sigma_c^2 \geq \sigma_o^2 = \xi \sigma_c^2$), (iii) the Sharpe ratio of the unsmoothed returns is $1/c(s)$ times lower than that of the observed returns ($Sh_c = \frac{1}{c(s)} Sh_o \leq Sh_o$, with $c(s) = 1/\xi \geq 1$). Thus, our corrected (unsmoothed) series must satisfy these three properties — which was the case.

This method is very attractive but nevertheless raises two problems, may be minor ones. On the one hand, it is based on the assumption that observed de-meaned returns follow a normal distribution. On the other hand, the estimate of the unsmoothed returns is "based" on the first return (if $k = 1$) or the first two returns (if $k = 2$), these returns being said to be "true" returns when these observed returns are, by nature, smoothed. This may create a potential bias. However, in our case, we have 34 cases with $k = 1$ and 6 cases with $k = 2$ while each case has 146 returns to be corrected, so this bias should be minor[7].

5 The unsmoothing process

After having measured the serial correlation level, the G-OW and GLM methods are conducted.

Regarding the G-OW method, a first correction is made according the equation 1.2 for all the indexes which have a serial correlation coefficient of order statistically significant. This process suppresses the serial correlation of all the indexes, including the 5 indexes which have a significant (at 5%) autocorrelation of order 2 and of which the coefficient is rather high in absolute value. The only exception is the index CSFB Convertible Arbitrage for which, in order to suppress the serial correlation of order 2, one has been obliged to use

[6]Applying $k = 2$ to a sample of 909 individual hedge funds having from 61 to 133 monthly returns, GLM obtained quite satisfactory results: the estimation procedure converges and all the $\hat{\theta}$ are positive, except for one.

[7]Nevertheless, we wonder if this would not be the reason why the corrections by the GLM method are generally smaller than those made by the G-OW method, even if – as it will be seen below – these corrections are very similar.

the Okunev & White (2003)'s extension.

As fas as the GLM method concerns, its subtle point is to choose the "right" k. The trial of $k = 2$ – which had been chosen by the authors – resulted in unsatisfactory results. Consequently, we used $k = 1$ for the 34 series with an autocorrelation of order 1 and $k = 2$ for the 6 series with an autocorrelation of order 2. In all these cases, the optimization process converges and the estimated thetas are positive and significant.

Table 2: Smoothing profiles computed by the GLM procedure

	Indexes	$\hat{\theta_0}$	$\hat{\theta_1}$	$\hat{\theta_2}$	ξ	$c(s)$	$1 - \frac{1}{c(s)}$
CSFB	Convertible Arbitrage	0.51	0.28	0.21	0.38	1.62	0.38
	Emerging Markets	0.76	0.24		0.63	1.26	0.20
	Equity Market Neutral (EMN)	0.81	0.19		0.69	1.21	0.17
	Event Driven	0.78	0.22		0.66	1.23	0.19
	Event Driven Distressed	0.81	0.19		0.69	1.21	0.17
	Event Driven Multi-strategy	0.79	0.21		0.66	1.23	0.19
	Event Driven Risk Arbitrage	0.76	0.24		0.63	1.26	0.21
	Fixed Income Arbitrage	0.72	0.28		0.60	1.29	0.23
	Long Short Equity	0.89	0.11		0.80	1.12	0.11
HFR	Convertible Arbitrage	0.54	0.31	0.16	0.41	1.57	0.36
	Distressed Security	0.73	0.27		0.60	1.47	0.32
	Emerging Markets (total)	0.77	0.23		0.65	1.25	0.20
	Emerging Markets (Asia)	0.66	0.19	0.15	0.49	1.42	0.30
	Equity Hedge	0.86	0.14		0.76	1.14	0.13
	EMN Statistical Arbitrage	0.86	0.14		0.76	1.15	0.13
	Equity Non Hedge	0.84	0.16		0.73	1.17	0.14
	Event Driven	0.79	0.21		0.67	1.22	0.18
	Fixed Income (total)	0.81	0.19		0.69	1.20	0.17
	Fixed Income Arbitrage	0.70	0.30		0.58	1.31	0.24
	Fixed Income High Yield	0.66	0.20	0.14	0.50	1.42	0.29
	FoF Conservative	0.77	0.23		0.64	1.25	0.20
	FoF Diversified	0.75	0.25		0.63	1.26	0.21
	FoF Strategic	0.80	0.20		0.68	1.21	0.17
	FoF Composite	0.78	0.22		0.65	1.24	0.19
	Fund Weighted Composite	0.83	0.17		0.72	1.18	0.15
	Merger Arbitrage	0.82	0.18		0.71	1.19	0.16
	Relative Value Arbitrage	0.69	0.18	0.14	0.52	1.38	0.28
	Sector	0.87	0.13		0.78	1.13	0.12
GV	Equity Market Neutral	0.83	0.17		0.72	1.18	0.15
	Event-Driven	0.80	0.20		0.68	1.21	0.17
	Distressed Securities	0.78	0.22		0.66	1.23	0.19
	Special Situations	0.82	0.18		0.70	1.19	0.16
	Market Neutral Arbitrage	0.72	0.28		0.60	1.29	0.23
	Convertible Arbitrage	0.55	0.32	0.13	0.42	1.53	0.35
	Fixed Income Arbitrage	0.77	0.23		0.65	1.24	0.20
	Opportunistic	0.88	0.12		0.79	1.13	0.11
	Value	0.85	0.15		0.74	1.16	0.14
	Market Timing	0.90	0.10		0.81	1.11	0.10
	Emerging Markets	0.85	0.15		0.75	1.16	0.14
	Multi-Strategy	0.84	0.16		0.73	1.17	0.15
	Mean				0.65		0.20
	Standard deviation				0.10		0.07
	Max				0.81		0.38
	Min				0.38		0.11

$\xi = \sum_{j=0}^{2} \hat{\theta}_j^2$ ($\xi \in [0.1]$) measure the smoothing level. A low ξ implies a high smoothing level. $\xi = 1$ indicates no smoothing. $c(s) = 1/\sqrt{\sum_{j=0}^{2} \hat{\theta}_j^2}$. GLM show that neglecting the serial correlation will underestimate the variance ξ by three ($\sigma_o^2 = \xi \sigma_c^2$) and overestimate the Sharpe ratio by $c(s)$ ($Sh_o = c(s) Sh_c$). ($1 - \frac{1}{c(s)}$) is the correction coefficient to be used to obtain the "true" Sharpe.

Table 2 presents the results of the process for each index according the GLM method.

The reader should be aware of the slight difficulty for interpreting the result, which should be "inversely" read. Theta zero chapeau is the percentage of the true returns included in the observed returns. Thus, more $\hat{\theta}_0$ chapeau is small, more the observed returns are smoothed. Theta 1 and theta 2 are the percentage of previous returns (return $t-1$ and return $t-2$) which are included in the observed return (return t). η is the smoothing index. The smaller η, the higher the smoothing level. $c(s)$ is the correction coefficient to be applied to the observed Sharpe ratio ($Sh_c = \frac{Sh_o}{c(s)}$). In other words, the observed Sharpe ratio is overestimated and should be diminished by $1 - 1/c(s)$ in order to measure the true Sharpe ratio. Our results show that 15 indexes of 40 have an average smoothing level since the "smoothing index" ranges between 0.69 and 0.60, the mean being 0.65 – which means for measuring the performances to lower the observed Sharpe ratio by 17 to 23%. These results show that the smoothing average is rather strong!

Seven indexes constitute a "large – smoothed" group of which eta is smaller than 0.60. Three of them are very noticeable, the three Convertible Arbitrage indexes (0.42, 0.41, 0.38). The Sharpe ratio should be on average diminished by 36%. Conversely, 14 indexes constitute "slight-smoothed" group of which eta is larger than 0.70. The less autocorrelated are CSFB Long Short Equity with 0.85 and GV Market Timing with 0.81. The Sharpe ratio should only be reduced by 10%.

The next procedure is to apply the estimated thetas into equation (8) in order to obtain the "unsmoothed" returns. These unsmoothed returns are theoretically the true returns. The next section presents the results.

6 Financial characteristics of "unsmoothed" returns

The following tables present two comparisons; on the one hand, the comparison between the original "smoothed" series and the corrected "unsmoothed" ones; on the other hand, the comparison between the results obtained under G-OW and GLM methods. The comparison of the distribution parameters emphasizes the risk indicators.

6.1 Similarity of obtained mean returns

The results are clear: the mean returns computed on the unsmoothed series are strictly identical in 18 cases (over 40 unsmoothed series)[8]. And the difference is only two units on the second decimal for the 22 other cases[9]. This equality conforms with the mathematical demonstration by GLM proving that the smoothing has no influence on the observed returns (and then on the expected returns for the future).

[8]In order to be short and because of the similarity, the figures on the mean returns are not presented here. They are available upon request.

[9]To be completely safe, a Student test on the mean of the three distributions was made. As the standard deviation is strictly equal, these means are statistically identical.

6.2 Strong increase of the risk

The hedge funds try to sell the idea that they are an asset with a reduced risk - hence, their name of "Hedge". Our results, in line with the theoretical and empirical previous ones, show that this image is wrong.

6.2.1 Large increase of the standard deviation[10]

The standard deviations of the unsmoothed series increase in average by 25% with the GLM method and by the 37% with the G-OW one. More unsmoothed are the series, more the increase in its risk. One finds again the 3 Convertible Arbitrage indexes for which the "true" risk increases by 73% for HFR, 84% for GV and 117% for CSFB! Follwing them are the two portfolios, Distressed Securities and Equity Market Neutral, each having an increase of 57%. Otherwise, the majority of hedge funds have a true risk which is higher by 30% to 40% than the "official" risk, which is quite a large increase!

Table 3: Comparison of standard deviations before and after the unsmoothing

Indexes	B	G-OW	GLM	G-OW *vs* B	Indexes	B	G-OW	GLM	G-OW *vs* B
CSFB					**HFR**				
Convertible Arbitrage	1.4	3.0	2.2	117.3	Convertible Arbitrage	1.0	1.8	1.7	73.3
Emerging Markets	4.7	6.3	5.9	33.1	Distressed Security	1.5	2.4	1.9	57.2
Equity Market Neutral (EMN)	0.8	1.1	1.0	34.1	Emerging Markets (total)	4.2	5.7	5.2	37.2
Event Driven	1.6	2.3	2.0	40.0	Emerging Markets (Asia)	3.6	5.2	5.0	46.5
Event Driven Distressed	1.8	2.4	2.2	32.4	Equity Hedge	2.6	3.1	3.0	19.3
Event Driven Multi-Strategy	1.8	2.4	2.1	38.6	EMN Statistical Arbitrage	1.1	1.4	1.3	23.0
Event Driven Risk Arbitrage	1.2	1.6	1.5	33.2	Equity Non Hedge	4.0	4.7	4.7	16.6
Fixed Income Arbitrage	1.1	1.6	1.3	48.7	Event Driven	1.8	2.4	2.2	31.2
Long Short Equity	3.0	3.4	3.3	14.1	Fixed Income (total)	0.9	1.2	1.0	35.6
GV					Fixed Income Arbitrage	1.1	1.6	1.5	42.6
Equity Market Neutral	1.2	1.5	1.4	25.0	Fixed Income High Yield	1.3	1.8	1.8	40.1
Event-Driven	1.7	2.3	2.1	33.2	FoF Conservative	0.9	1.4	1.2	44.4
Distressed Securities	1.4	1.9	1.7	36.3	FoF Diversified	1.8	2.5	2.2	41.3
Special Situations	2.0	2.6	2.4	29.4	FoF Strategic	2.6	3.5	3.1	33.6
Market Neutral Arbitrage	0.9	1.4	1.2	57.0	FoF Composite	1.7	2.3	2.0	38.0
Convertible Arbitrage	1.1	2.0	1.6	86.7	Fund Weighted Composite	2.0	2.5	2.4	23.2
Fixed Income Arbitrage	1.0	1.4	1.2	46.7	Merger Arbitrage	1.1	1.4	1.3	29.1
Opportunistic	2.9	3.4	3.3	17.5	Relative Value Arbitrage	0.9	1.2	1.3	37.3
Value	3.0	3.5	3.5	18.8	Sector	4.1	4.9	4.7	17.7
Market Timing	2.6	2.9	2.8	15.0					
Emerging Markets	5.0	6.0	5.7	21.7					
Multi-Strategy	2.3	2.7	2.6	20.7					
Mean						2.0	2.7	2.5	37.2
Standard deviation						1.1	1.4	1.3	20.0

B: original series; G-OW: series unsmoothed following the G-OW method; GLM: series unsmoothed following the GLM method; G-OW *vs* B: variation (in %) of standard deviations unsmoothed by G-OW relative to standard deviations of original series (the correction providing the largest differences).

In order to have a formal proof, 80 Fisher tests on equality of variances have been made: smoothed variances versus unsmoothed G-OW variances and smoothed variances versus unsmoothed GLM variances. In all the cases, the equality of the two variances (observed

[10]We analyze the statistical properties of the unsmoothed and smoothed distribution of returns, we focus on the standard deviation and not on the volatility.

variances and corrected variances) is rejected at minimum 5%. The conclusion is clear-cut: the hedge funds indexes present a risk level larger than the observed risk and their "true" risk is at least 25% larger than their "official" risk. Since an index is a portfolio of individual funds, it is obvious than some individual risks are dramatically larger.

The comparison of the two methods shows that the standard deviations corrected by G-OW are larger than those computed by the GLM procedure (with only two exceptions where they are equal). On average, the G-OW standard deviations are larger than 7.4%[11] .

6.2.2 Lack of skewness effect

The third distributional parameter - skewness - has to be taken into account as a (minor) risk parameter. Here, as for almost all the portfolios invested on stock exchange, the skewness of the hedge funds indexes is negative: 31 cases for the unsmoothed skewness and 28 (over 40) for the smoothed ones. But, that skewness does not seem really relevant parameter, the more so the unsmoothing improves the skewnesses: the average for the 40 smoothed skewnesses is -0.91 while the average of the skewnesses is -0.76 for the G-OW unsmoothing procedure and -0.81 for the GLM one[12].

6.2.3 Heterogeneity of kurtosis

The fourth distributional parameter - kurtosis - is a risk parameter if the computed coefficient is positive[13], it means (to put it very simply) that the probability for a krach, either up or down, is larger than 5%. The distributions of hedge fund returns definitely have fat tails: on average, the "smoothed" excess of kurtosis is 7.26 while that of the "unsmoothed" is 7.11 according to G-OW or 7.20 according GLM. A formal Student test on these three means concludes that the krach risk is identical for "smoothed" and "unsmoothed" returns.

But this similarity of the mean hides the presence of three groups very different in this aspect. There are nine indexes with a very high kurtosis (according to GLM), larger than 10: six between 10 and 20; especially three between 20 and 30 with GV Fixed Income Arbitrage reaching 39. The second group is composed by a majority of 26 indexes having a kurtosis (according to GLM) between 1 and 9. Finally, a small group of five indexes whose kurtosis (according to GLM) is lower than 1 and which certainly have a "true" kurtosis equal to zero.

[11] But 40 Fisher tests show that this average difference of 7.4% is not significant, the variances being statistically equal.

[12] A formal Student test shows that the two G-OW and GLM averages are statistically equal. The individual results are shown in the appendix (table 10).

[13] A normal distribution has a kurtosis equal to 3. But, softwares generally compute the excess of kurtosis ($= k - 3$), so that the coefficient is de-meaned on zero. It is the case of our computation (cf. appendix, table 10).

6.3 Increase of potential maximum loss

It seems interesting to study what can be the maximum loss that an investor in hedge funds bears. The Modified Value-at-Risk (MVAR) proposed by Favre & Galeano (2002) has the attractive property of taking into account the four parameters of return distributions, mainly skewness and kurtosis:

$$MVAR = W\left[\mu - \left\{z_c + \frac{1}{6}\left(z_c^2 - 1\right)S + \frac{1}{24}\left(z_c^3 - 3z_c\right)K - \frac{1}{36}\left(2z_c^3 - 5z_c\right)S^2\right\}\sigma\right] \quad (9)$$

with W portfolio value exposed to risk, $\mu = \overline{R}$ mean return, σ, S et K standard deviation, skewness and excess of kurtosis of returns respectively; z_c critical value corresponding to $1 - \alpha$ significance level ($z_c = -1.96$ when $\alpha = 95\%$).

The results (see appendix, table 10) summarize the preceding results: MVAR according to G-OW and GLM is systematically larger than that computed on the smoothed returns. This shows the effect of the increase in standard deviations and that of the kurtosis (more or less strong) and also asserts the probable lack of effect of the skewness, although it is negative. The difference between the smoothed and unsmoothed MVAR ranges between 12% and 98% according to G-OW and between 5% to 52% according to GLM. It is clear that the smoothing of the returns of some hedge fund strategies hides their risk. It should be noticed that the G-OW procedure gives MVAR values on average larger by 10% than those computed by the GLM method.

To summarize, the comparison of statistical parameters and their financial implications between the smoothed and unsmoothed return series gives three basic results:

- First, the smoothing of returns (either natural or intentional) reduces the three parameters measuring the total risk of a fund: the standard deviation, the skewness and the kurtosis - the principal decrease being that of the standard deviation.
- Consequently, this decrease dramatically hides the "true" risk level of some hedge fund strategies. The smoothing creates real illusion, especially for the riskiest strategies.
- Finally, the choice of the unsmoothing method (G-OW or GLM) seems neutral, the results being very similar: the same direction and the same numerical values.

7 Consequences of the unsmoothing on hedge fund performances

The ultimate aim for correcting the hedge fund returns is to measure their "true" performances.

7.1 Decrease of the absolute performance

Two performance measures are used: the Sharpe ratio (Sharpe 1966) because of its large popularity and the Omega ratio (Keating & Shadwick 2002) which has the advantage to take into account the whole return distribution without making any assumption neither on the distribution law, nor on the investor's utility function.

The computation of the Sharpe ratio for the smoothed and unsmoothed series is very traditional: average standard deviation of the relevant return distribution and the risk-free rate of interest is that of the US 3-month Treasury bill[14]. The formula for the Omega ratio is the following:

$$\text{Omega}(\tau) = \Omega(\tau) = \frac{\int_{\tau}^{\infty}[1 - F(R)]dR}{\int_{-\infty}^{\tau} F(R)dR} = \frac{I_g}{I_l} \quad (10)$$

The Omega coefficient is the ratio of the gains (I_g) and the losses (I_l) relative to a threshold τ, which is freely determined by the investors; the gains and losses are weighted by their occurrence frequency. τ is also the US 3-month Treasury bill. The higher the Omega ratio, the larger the performance.

The smoothed Sharpe ratios show a very attractive image for the hedge funds since the general average is 1.16 and, even four strategies exceed 2. Curiously, there are some "losers", especially the strategies on the Emerging Markets which gets only 0.30. Of course, the ratios of the unsmoothed returns are much less flattering since the G-OW method decrease these ratios on average by 25% and the GLM method by 20%. For example, the average of the 40 ratios decreases, according to G-OW, from 1.16 to 0.86 with a maximum of 1.58 (instead of 2.16) and a minimum of 0.18 (instead of 0.28).

Table 4: Changes in absolute performances for the 40 smoothed indexes

	Panel A: Sharpe ratio					
	Absolute value				Variation (%)	
	B_S	B_{NS}	G-OW	GLM	G-OW	GLM
Mean	1.16	0.64	0.80	0.84	-24.9	-20.4
Standard deviation	0.53	0.54	0.42	0.46	8.8	10.4
Max	2.16	1.27	1.58	1.74	-8.2	-5.7
Min	0.28	-0.32	-0.32	-0.32	-48.2	-51.0
S&P 500	**0.49**					
	Panel B: Omega index					
Mean	2.42	1.65	1.83	1.97	-18.6	-12.6
Standard deviation	0.99	0.60	0.59	0.74	9.5	6.0
Max	4.72	2.54	3.49	3.87	-4.8	-3.8
Min	1.17	0.75	0.75	0.75	-41.0	-28.4
S&P 500	**1.36**					

B_S: values of original series; B_{NS}: values of non-smoothed original series; G-OW: values smoothed by the G-OW method; GLM: values smoothed by the GLM method; all variations (in %) are computed in comparison with the value of the original series.

Table 5 shows in a synthetic way the differences in the distribution of the Sharpe ratios

[14]Technically, the Sharpe ratio is computed on monthly returns. The result is multiplicated by "$\sqrt{12}$" in order to be "annualized".

between the three series: the smoothed, that unsmoothed by G-OW and that unsmoothed by GLM. The shift to the lower class is obvious[15].

Table 5: Distribution of Sharpe ratios for the 40 smoothed and unsmoothed indexes

Sharpe ratio	Original	G-OW	GLM
Sh $\leq$ 0.5	4	7	8
0.5 < Sh <1	14	18	16
1$\leq$ Sh < 1.5	12	13	12
1.5 $\leq$ Sh < 2	6	2	4
Sh $\geq$ 2	4	0	0
Total	40	40	40
Average of Sharpe	1.16	0.86	0.91

The Omega shows the same shift to the lower class when the G-OW method is used. But these shifts are less noticeable with the GLM procedure. That method keeps in the highest class (ratios larger than 3) six out of the seven funds of which the unsmoothed returns did belong[16].

7.2 Significant changes in hedge fund rankings

In fact, what matters to the managers is less the absolute value of the performance coefficients than their ranking among their peers. Hence, the consequences of the unsmoothing on rankings have to be analyzed. For that, an important methodological point should be raised: the 14 indexes which had no serial correlation and then which have not been unsmoothed have to be reintroduced in the sample. This inclusion is important in two respects; theoretically because one can expect the non-smoothed funds to be systematically disadvantaged by the rankings; practically because the performance measurements are made on all the funds belonging to a given strategy.

7.2.1 Strange similarity of the global ranking

Unexpectedly, the five rankings obtained are very similar. The correlation coefficients between the ranks are very large, as shown by table 6 below[17].

A much stronger difference was expected. Nevertheless, three things are worth to be noticed. On the one hand, the necessary inclusion of the non-smoothed indexes brings a light increase in differences. Secondly, the ranking similarity is somewhat smaller when the G-OW is used. Finally, the two corrective methods bring very similar results. Which means that the unsmoothing, whatever the procedure used, has no actual consequences on

[15]The readers can notice (even if it is not our topic) that to obtain a Sharpe ratio of 0.86 (or 0.91) can be considered as very good relatively to a portfolio of US stocks represented by S&P 500 which obtains only half of that, 0.49.

[16]The detailed results concerning the Omega ratio are available upon request.

[17]Detailed rankings are available upon request.

Table 6: Spearman correlation coefficients between the performance rankings

	Smoothed indexes only		*Smoothed indexes and NON smoothed*	
	Sharpe	Omega	*Sharpe*	*Omega*
Original *vs* G-OW	0.963	0.964	*0.942*	*0.934*
Original *vs* GLM	0.952	0.983	*0.947*	*0.97*
G-OW *vs* GLM	0.994	0.991	*0.994*	*0.986*

the relative rankings of hedge funds. Because of the important financial implications of the fund rankings, it needs to be examined in more details.

7.2.2 An improved distribution of non-smoothed indexes among the quartiles

It is interesting to analyze the changes among quartiles when the funds have been unsmoothed. This analysis is made in the following manner. The funds are first ranked in a decreasing order according to their performance ratios on the smoothed and unsmoothed returns. This ranking is then divided in four groups with now 54 indexes; the two first quartiles include 13 indexes each while the two last quartiles group 14 indexes.

The table 7 below tends to confirm the intuition according to which the non-smoothed hedge funds are systematically disadvantaged.

Table 7: Quartile ranking distribution of the indexes according to the Sharpe ratio (before and after the unsmoothing according to the G-OW method)

	Q*1	**Q*2**	**Q*3**	**Q*4**	**Total**
Smoothed indexes					
Before the unsmoothing	13	9	9	9	40
Before the G-OW unsmoothing	10	11	10	9	40
in %	25	27,5	25	22,5	100
Non-smoothed indexes					
Before the unsmoothing	0	4	5	5	14
After the G-OW unsmoothing	**3**	3	3	*5*	14
in %	21	21	21	36	100

* Q denotes quartiles. The total sample includes 54 indexes, among them 40 display a serial correlation and are thus corrected.

Before the correction, none of the 14 non-smoothed indexes belongs to the first quartile, which groups the best performing funds. After correcting the smoothed indexes with the G-OW method, the non-smoothed indexes profit from a general upper shift, with specially three indexes – CSFB Multi Strategies, HFR Equity Market Neutral and HFR Market Timing – which reach the first quartile. On the contrary, the last four funds in the rankings based on the smoothed series are still the last ones after the correction. This finding shows that two kinds of non-smoothed indexes do exist: the "good" ones which are disadvantaged if there is no correction procedure; and the "second-rate" ones which do not profit from the correction of the smoothed competitors. The detailed analyses either on the rankings according to the Omega ratios or according to the GLM procedure bring the same results.

To sum up, the first effect of the corrective procedure is to improve the rankings of the non-smoothed indexes and correlatively to degrade the rankings of the smoothed indexes.

7.2.3 Significant changes in performance classes

Except to be either "the first" or "the last" ones, the manager wishes to belong to the "good" ones, meaning to be in the first class. The empirical way to measure that is to look into the changes between the quartiles. Table 8 presents these changes between quartiles according to the corrective method used and according to the performance ratio.

Table 8: Changes between quartiles for the different rankings of 54 indexes

	Panel A: Sharpe							
	G-OW				GLM			
	smoothed		Non-smoothed		smoothed		Non-smoothed	
	Nbr	%	Nbr	%	Nbr	%	Nbr	%
Shift to a LOWER quartile	5	12.5	0	0.0	4	10.0	0	0.0
Maintain in the same quartile	34	85.0	10	71.4	33	82.5	11	78.6
Shift to a HIGHER quartile	1	2.5	4	28.6	3	7.5	3	21.4
Equality of ranks	2	5.0	4	7.4	6	42.9	3	21.4
Variation of ONE place (upwards or downwards)	13	32.5	1	1.9	12	85.7	1	7.1
	Panel B: Omega							
	G-OW				GLM			
	smoothed		Non-smoothed		smoothed		Non-smoothed	
	Nbr	%	Nbr	%	Nbr	%	Nbr	%
Shift to a LOWER quartile	5	12.5	0	0.0	4	10.0	0	0.0
Maintain in the same quartile	33	82.5	11	78.6	35	87.5	12	85.7
Shift to a HIGHER quartile	2	5.0	3	21.4	1	2.5	2	14.3
Equality of ranks	7	17.5	3	21.4	6	15.0	3	21.4
Variation of ONE place (upwards or downwards)	9	22.5	0	0.0	13	32.5	1	7.1

The previous rank correlation coefficients are verified: 81% of the total sample (44 indexes out of 54) or 82.5% of the smoothed indexes (being unsmoothed) remain in the same quartile (whatever the corrective procedure used). But this also means that 12.5% of the smoothed funds (9% of the sample) are down-graded while 21% of the non-smoothed funds are over-graded according to the Omega ratio and 29% according to the Sharpe ratio.

It seems to us that to prove that 19% of the funds suffer from the "unsmoothing" is an important result from an academic as from a practical points of view. Indeed, the performances result in money inflows, and, as shown in section 1 these inflows influence the manager compensation scheme. It is thus important to have an idea about the changes in rankings.

7.2.4 Example of individual variations of performance rankings

Tableau 9 presents some examples of the most significant (upward or downward) changes of fund's ranks on the basis of Sharpe ratio obtained from returns corrected by the G-OW method.

Table 9: Examples of rank changes on the basis of the Sharpe ratio and the G-OW correction method

	Original	G-OW	Difference
Cases having the highest downward variations			
HFR Convertible Arbitrage	11	26	-15
CSFB Convertible Arbitrage	29	42	-13
GV Convertible Arbitrage	2	11	-9
CSFB Event Driven	17	24	-7
HFR FoF Conservative	22	29	-7
Cases having the highest upward variations*			
HFR Market Timing	25	13	+12
GV Income	26	15	+11
CSFB Multi Strategies	20	10	+10
HFR Equity Market Neutral	16	7	+9

Indexes in *italic* are non-smoothed ones. * The three indexes which follow these four indexes and win 7 places are all non-smoothed indexes.

8 Concluding remarks

In this research, we have used two methods which eliminate the serial correlation found in hedge fund returns and which recreate "unsmoothed" returns: the procedure proposed by Geltner (1993), its extension by Okunev & White (2003) and that developed by Getmansky, Lo & Makarov (2004). Our empirical analysis is based on a sample of 54 hedge fund indexes representing hedge fund portfolios. Our main conclusions concern the consequences of the unsmoothing and of the method used for the unsmoothing on the financial characteristics of the hedge fund returns and on their performance measurement. Several findings are noteworthy.

Firstly, the hedge fund financial characteristics after the unsmoothing process are strongly modified. If the mean return does not change, the risk level increases considerably. According to the corrective method, the standard deviation increases on average by 25% and even by 37%; the skewness does not seem to have an impact contrarily to the excess of kurtosis which shows that a large majority of hedge funds bears an "abnormal" risk of a downward crash. These two last empirical evidences are a original contribution to the literature which has only dealt with the standard deviation of returns and which has neglected the third and fourth moments of the return distribution.

The consequence is that the hedge fund performance measured by traditional ratios considerably decreases after unsmoothing, decrease which is on average 20%, even 25%

according to the method and to the performance ratio used. If a cursory look can give the feeling that the rankings are not really modified, more detailed analysis shows that 20% of have a change in rankings. Moreover, there are several cases of strong "down-grading" and of strong "over-grading" - these later correcting the disadvantage borne by the non-smoothed indexes when they are compared to the smoothed ones.

Finally, the choice of the unsmoothing procedure seems neutral, the results being very similar when they are not identical. One can only note that the G-OW is "stronger" in the down-grading of the performances, certainly because this method diminishes more significantly the standard deviation than does the GLM method. Since this G-OW procedure seems easier to understand and easier to implement, we believe it could be chosen by practionners concerned.

These three sets of results have important implications for the hedge fund managers as for the regulating authorities. We confirm the fact that partially for natural reasons and partially intentional ones, returns of several hedge fund strategies are smoothed. Not taking into account this characteristic means to underestimate strongly the risk level borne by investors and to overestimate the performances of these funds. In a time when everyone is correctly concerned by "ethic behaviour" and by "good governance", the transparency demands the true risk level of hedge funds to be measured/ connu and the moral requires the managers to be "rated" on the basis of their true performances.

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Appendix

Table 10: Characteristics of unsmoothed indexes: skewness, kurtosis, MVAR and normality test

Indices	Skewness					Excess of Kurtosis (= $K-3$)					MVAR					Shapiro-Wilk Test		
	Absolute Value			Variation (%)		Absolute Value			Variation (%)		Absolute Value			Variation (%)		B	G-OW	GLM
	B	G-OW	GLM	G-OW	GLM	B	G-OW	GLM	G-OW	GLM	B	G-OW	GLM	G-OW	GLM			
CSFB																		
Convertible Arbitrage	-1.36	-0.59	-1.20	-57	-11	3.09	5.12	4.10	66	32	4.24	8.38	6.44	98	52	0.90	0.93	0.92
Emerging Markets	-0.71	-0.96	-1.00	34	40	4.83	5.43	5.53	12	14	12.79	17.43	16.45	36	29	0.93	0.93	0.93
Equity Market Neutral (EMN)	0.32	0.21	0.26	-35	-18	0.43	0.94	0.77	120	80	2.38	3.01	2.73	27	15	0.99	0.98	0.98
Event Driven	-3.59	-3.84	-3.83	7	7	25.57	29.65	29.69	16	16	6.67	9.29	8.16	39	22	0.76	0.75	0.75
Event Driven Distressed	-3.04	-3.18	-3.16	5	4	19.93	22.83	22.38	15	12	7.37	9.80	8.80	33	19	0.80	0.79	0.80
Event Driven Multi-Strategy	-2.63	-2.62	-2.68	0	2	17.14	18.41	19.22	7	12	6.75	9.27	8.28	37	23	0.82	0.83	0.83
Event Driven Risk Arbitrage	-1.26	-1.17	-1.23	-7	-2	6.52	7.11	7.49	9	15	3.99	5.18	4.93	30	24	0.92	0.92	0.91
Fixed Income Arbitrage	-3.34	-1.72	-2.12	-49	-37	19.00	11.00	12.46	-42	-34	3.95	5.43	4.80	37	22	0.76	0.84	0.83
Long Short Equity	0.23	0.14	0.18	-39	-20	3.99	3.56	3.62	-11	-9	7.33	8.28	8.01	13	9	0.94	0.95	0.95
HFR																		
Convertible Arbitrage	-1.01	-0.36	-0.84	-64	-16	2.05	3.15	3.28	54	60	3.31	5.01	4.88	51	48	0.94	0.96	0.95
Distressed Security	-1.72	-1.70	-1.77	-2	3	9.81	10.96	11.12	12	13	5.61	8.44	6.97	51	24	0.90	0.89	0.89
Emerging Markets (total)	-0.96	-1.18	-1.21	23	26	5.05	5.59	6.02	11	19	11.90	16.36	15.05	38	26	0.94	0.93	0.93
Emerging Markets (Asia)	0.21	0.22	0.24	5	18	0.59	0.23	0.09	-61	-84	7.37	10.34	9.83	40	33	0.98	0.99	0.99
Equity Hedge	0.28	0.29	0.33	5	18	1.91	1.52	1.65	-21	-13	6.23	7.09	6.81	14	9	0.98	0.98	0.98
EMN Statistical Arbitrage	-0.30	-0.26	-0.28	-13	-8	0.35	0.04	0.10	-87	-70	2.95	3.44	3.26	17	10	0.99	0.99	0.99
Equity Non Hedge	-0.50	-0.42	-0.41	-14	-18	0.66	0.45	0.42	-32	-36	10.11	11.40	11.39	13	13	0.98	0.99	0.99
Event Driven	-1.30	-1.12	-1.13	-14	-13	5.63	5.20	5.26	-8	-7	6.08	7.51	7.06	24	16	0.93	0.94	0.94
Fixed Income (total)	-1.31	-0.99	-1.18	-25	-10	5.16	3.99	4.77	-23	-8	3.00	3.68	3.40	23	13	0.91	0.93	0.92
Fixed Income Arbitrage	-3.32	-2.03	-1.69	-39	-49	18.96	11.45	8.81	-40	-54	4.00	5.31	4.75	33	19	0.73	0.84	0.87
Fixed Income High Yield	-2.12	-2.10	-2.16	-1	2	10.20	12.59	12.72	23	25	4.41	6.23	6.27	41	42	0.86	0.86	0.86
FoF Conservative	-0.54	-0.76	-0.72	42	34	4.12	4.56	4.33	11	5	2.94	4.10	3.56	39	21	0.94	0.94	0.94
FoF Diversified	-0.09	-0.33	-0.27	281	213	4.76	4.21	4.49	-11	-6	4.75	6.60	5.92	39	25	0.93	0.94	0.94
FoF Strategic	-0.44	-0.49	-0.42	11	-4	4.53	4.15	4.34	-8	-4	7.09	9.19	8.30	30	17	0.94	0.95	0.95
FoF Composite	-0.25	-0.44	-0.37	76	47	4.61	4.19	4.43	-9	-4	4.62	6.22	5.58	35	21	0.94	0.95	0.95
Fund Weighted Composite	-0.52	-0.49	-0.47	-5	-9	3.24	2.75	2.85	-15	-12	5.81	6.83	6.55	18	13	0.96	0.97	0.97
Merger Arbitrage	-2.02	-1.81	-1.85	-10	-8	9.31	8.72	8.66	-6	-7	3.97	4.86	4.51	22	14	0.88	0.89	0.89
Relative Value Arbitrage	-2.62	-2.47	-2.51	-6	-4	18.52	17.97	17.93	-3	-3	3.90	5.08	5.26	30	35	0.84	0.84	0.84
Sector	0.24	0.27	0.30	13	23	3.07	2.67	2.81	-13	-9	9.70	10.98	10.59	13	9	0.95	0.96	0.96
GV																		
Equity Market Neutral	1.25	1.08	1.18	-13	-5	4.65	4.62	5.01	-1	8	2.81	3.46	3.23	23	15	0.92	0.92	0.92
Event-Driven	-0.44	-0.17	-0.18	-62	-60	4.90	5.03	5.12	3	4	5.32	6.50	6.01	22	13	0.94	0.94	0.94
Distressed Securities	-0.13	0.09	0.03	-170	-121	2.93	3.65	3.26	25	11	4.18	5.20	4.77	24	14	0.96	0.95	0.96
Special Situations	-0.26	0.02	0.00	-106	-101	4.26	4.33	4.45	2	4	5.83	6.92	6.47	19	11	0.94	0.94	0.94
Market Neutral Arbitrage	0.33	0.70	0.56	113	70	0.97	1.20	0.67	23	-31	2.60	3.26	2.88	25	11	0.98	0.97	0.98
Convertible Arbitrage	-0.85	0.09	-0.21	-111	-75	1.90	2.39	2.07	26	9	3.51	5.10	4.51	45	28	0.95	0.96	0.97
Fixed Income Arbitrage	-4.54	-4.11	-4.52	-9	0	38.07	36.18	38.68	-5	2	4.43	6.37	5.29	44	20	0.68	0.68	0.67
Opportunistic	1.76	1.77	1.85	1	5	10.12	10.15	10.59	0	5	5.32	5.96	5.61	12	6	0.86	0.87	0.87
Value	-0.35	-0.26	-0.25	-27	-28	1.38	1.05	1.12	-24	-19	7.89	8.91	8.77	13	11	0.98	0.99	0.99
Market Timing	1.01	0.87	0.92	-14	-8	3.04	2.60	2.78	-14	-9	4.92	5.73	5.48	16	11	0.94	0.95	0.94
Emerging Markets	-0.26	-0.37	-0.38	44	49	3.15	3.20	3.28	2	4	12.31	15.07	14.37	22	17	0.96	0.95	0.95
Multi-Strategy	-0.42	-0.35	-0.35	-17	-18	1.95	1.64	1.73	-16	-12	6.18	7.11	6.93	15	12	0.97	0.98	0.98
Mean	-0.91	-0.76	-0.81	-6	-2	7.26	7.11	7.20	0	-2	5.71	7.36	6.82	30	20	0.91	0.92	0.92
Standard deviation	1.38	1.27	1.32	67	51	8.05	7.94	8.20	33	29	2.65	3.37	3.20	16	11	0.08	0.07	0.07

B: values of original series; G-OW: values of series unsmoothed by the G-OW method; GLM: values of series unsmoothed by the GLM method; all variations (in %) are computed in comparison with the values of original series. Shapiro-Wilk Test is a normality test on return distributions. MVAR: Modified *Value-at-Risk* computed following the equation (9).