Original Article

Does size affect mutual fund performance? A general approach

Received (in revised form): 8th April 2011

Laurent Bodson

is a KBL assistant professor of Financial Management at HEC Management School – University of Liège. Laurent teaches several courses in finance and regularly provides executive seminars. Laurent is also a co-founder and head of asset management at Gambit Financial Solutions SA. His areas of expertise include portfolio and risk management, as both a practitioner and researcher. He has an extensive experience in non-Gaussian frameworks and he is specialized in investment and style analysis.

Laurent Cavenaile

is an associate researcher for the KBL Chair in Fund Industry at HEC Management School – University of Liège. He holds a master in economics from the University of Liège (Belgium) and an MSc in financial economics from Maastricht University (Netherlands).

Danielle Sougné

is a professor of finance at HEC Management School, University of Liège, Belgium. She holds a PhD in finance from the Catholic University of Louvain, Belgium. She is an active teacher in the bank sector and handles a wide range of financial courses, ranging from fundamental to advanced levels of specialization for professionals. As a holder of the KBL Chair in Fund Industry at HEC, she carries out research on fund management and administration in an international context.

Correspondence: Laurent Bodson, HEC-Management School, University of Liege, rue Louvrex, 14 (N1), Liege 4000, Belgium
E-mail: l.bodson@gambit-finance.com

ABSTRACT In this article, we study the potential relationship between mutual fund size and performance in a general framework. We sequentially test for a linear and a quadratic relationship using several traditional performance measures, as well as a new measure, on the basis of multi-factor models. We find evidence of a concave quadratic relationship between mutual-fund performance and size, which implies the existence of an optimal medium size in terms of performance.

Journal of Asset Management (2011) **12,** 163–171. doi:10.1057/jam.2011.30;
published online 19 May 2011

Keywords: mutual funds; performance; size; assets under management; quadratic regression; concave relationship

INTRODUCTION

Academic researches regarding the impact of size on fund performance does not provide clear-cut results. Although most of the literature finds a negative relationship between performance and asset size, some authors confirm a positive relationship (see Table 1). These opposite results are observed for both mutual funds and hedge funds.

A negative relationship suggests that size erodes performance. Perold and Salomon (1991) already showed there are diseconomies of scale in active management stemming from the increased costs associated with larger transactions. For Chen *et al* (2004), fund size erodes performance in the mutual fund industry because of liquidity and organizational diseconomies. Yan (2008), consistent with Chen *et al* (2004), founded a significant inverse relation between fund size and fund performance. This inverse relation is stronger among funds that hold less liquid

Table 1: Summary of the existing literature on size-performance relationship

Authors	*Period*	*Fund universe*	*Size–performance relationship*	*Performance measures*
Agarwal *et al* (2004)	1994–2000	Hedge funds	Linear–negative	Returns
Cheng *et al* (2004)	1962–1999	Mutual funds	Linear–negative	Performance measures based on factor models
Fuss *et al* (2009)	2005–2006	Hedge funds	Linear–negative	Returns
Herzberg, Mozes (2003)	1990–2001	Hedge funds	Linear–negative	Returns, Sharpe ratio
Yan (2008)	1993–2002	Mutual funds	Linear–negative	α
Amenc *et al* (2004)	1996–2002	Hedge funds	Linear–positive	α
Liang (1999)	1992–1996	Hedge funds	Linear–positive	Returns
Ding *et al* (2009)	1994–2005	Hedge funds	Linear–negative (returns) Linear–positive (Sharpe ratio)	Returns, Sharpe ratio
Ammann, Moerth (2005)	1994–2002	Hedge funds	Quadratic–concave	Returns, α, Sharpe ratio
Getmansky (2004)	1994–2002	Hedge funds Funds of Hedge funds	Quadratic–concave	Returns
Hedges (2003)	1995–2001	Hedge funds	Quadratic–concave	α
Indro *et al* (1999)	1993–1995	Mutual funds	Quadratic–concave	Returns
Xiong *et al* (2009)	1995–2006	Hedge funds	Quadratic–concave	Returns, α, Sharpe ratio
Clark (2003)	1991–2001	Mutual funds	No correlation	Returns, risk-adjusted returns
Gregoriou and Rouah (2003)	1994–1999	Hedge funds Funds of Hedge funds	No correlation	Returns, Sharpe ratio, Treynor ratio
Guidotti (2009)	2003–2008	Hedge funds	No clear relation	α

portfolios and is also more pronounced among growth and high turnover funds that tend to have high demands for immediacy. His findings suggest that liquidity is an important reason why fund size erodes performance. Hedges (2004) showed that smaller funds outperform larger funds, whereas mid-sized funds underperform both smaller and larger funds. Agarwal *et al* (2004) examined the role of fund size, past flows, managerial incentives, lockup and restriction periods on the cross-sectional variation in fund performance. Their findings suggest that funds with larger size and higher flows are associated with poor future performance. Hedge funds must therefore face decreasing returns to scale. Fuss *et al* (2009) confirmed that experience and size have a negative effect on performance, with a positive curvature at the higher quantiles. At lower quantiles, however, size has a positive effect with a negative curvature. Both factors show no significant level at the median.

A positive relationship implies that growth in fund size is desirable. For Zera and Madura (2001), larger fund size is associated with smaller expense percentages. Indeed, they focused on a significant negative relationship between expense percentages and both individual fund size and fund family size. Latzko (1999) concluded that there are economies of scale in bond funds, as a fund's cost elasticity is found to be less than unity. Amenc *et al* (2004) demonstrated that the mean α for large funds exceeds the mean α for small funds.

Other authors highlighted the existence of an optimal fund size. For Indro *et al* (1999), mutual funds must attain a minimum fund size in order to achieve sufficient returns to justify their costs of acquiring and trading information. Furthermore there are diminishing marginal returns to information acquisition and trading, and the marginal gains become negative when the mutual fund exceeds its optimal fund size. Getmansky (2004) also focused on optimal fund size. She showed that the asset size–performance relationship varies among different hedge fund categories, most of which are quadratic and concave, which indicates that an optimal asset size can be obtained. Ammann and Moerth (2005) analyzed the impact of fund size with respect to fund returns, standard deviations, Sharpe ratios and α derived from a multi-asset class factor model. Empirical evidence is revealed for a quadratic relationship between fund size and returns using a cross-sectional regression technique. Xiong *et al* (2009) also focused on a quadratic relationship.

In contrast, consistent with Clark (2003), Gregoriou and Rouah (2003) found little-to-no correlation between size and performance although they acknowledge that the data set used in the study suffered from survivorship bias. The study of Guidotti (2009) found no clear size effect on performance as it is positive for some hedge fund strategies and negative for others. A summary of the results from this existing literature are reported in Table 1.

We can notice that the existing literature does not provide a unique answer to the relationship between fund size and performance, which is alternatively shown to be negative, positive, quadratic or even inexistent. Recently, Ding *et al* (2009) have shown that the direction of the causality may be influenced by the performance measure used. In this context, we check the robustness of our results to different commonly used performance measures, as well as to a multi-factor performance measure proposed by Bodson *et al* (2010). In addition, we propose a global approach to the relationship between fund size and performance in the sense that we not only test potentially linear, but also quadratic relationship.

The rest of this article is organized as follows. We first present our dataset. We then successively present the methodology that we use to test a linear and quadratic relationship between mutual fund size and performance and discuss the results. Eventually, we comment on the characteristics of the new performance measure of Bodson *et al* (2010) in this context. The last section concludes.

DATA

We use data of about 2926 mutual funds with monthly observations between January 2000 and June 2010 (126 months). Monthly returns and total net asset values are retrieved from the CRSP mutual fund database. Our database contains 1652 equity mutual funds, 1044 bond mutual funds and 230 mixed allocation mutual funds, with both dead funds (361) and active funds (2565), which enables us to avoid potential survivorship bias (see Figure 1). All funds are active at the beginning of the analyzed period. For the parts of our analysis which requires factor models, we use the market, size and book-to-market factors of Fama and French (1992), as well as the Carhart (1997) momentum factor available on the Kenneth French's website.[1] Average assets and returns are reported in Table 2 by deciles (and sorted by total net asset values).

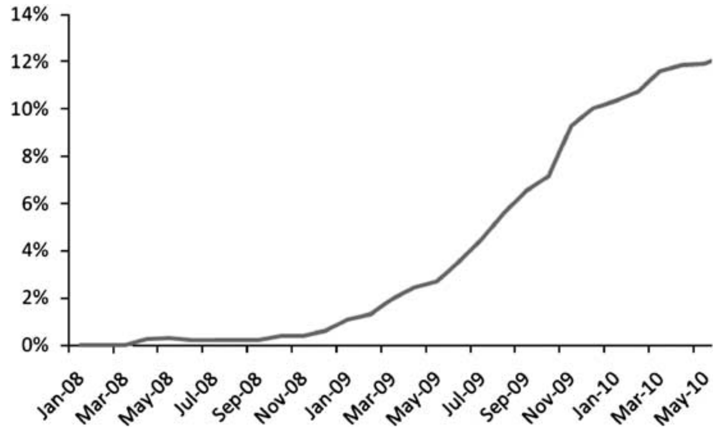

Figure 1: Percentage of dead funds in the database.

Table 2: Average size and return by deciles

Percentiles	*Average assets (million USD)*	*Average return (monthly) (%)*
91st–100th	8061.81	0.30
81st–90th	1311.69	0.36
71st–80th	598.64	0.35
61st–70th	335.85	0.35
51st–60th	196.22	0.37
41st–50th	118.49	0.40
31st–40th	71.58	0.38
21st–30th	39.46	0.32
11th–20th	18.15	0.32
1st–10th	4.26	0.28

From Table 2, we can observe that there is an average quadratic concave relationship between average size and average return in the database. This would suggest that there might be an optimal size with respect to performance (if summarized in the average return). This analysis is deepened in the following sections in order to rigorously verify the statistical significance of this relationship.

DOES SIZE ERODE MUTUAL FUND PERFORMANCE?

In this section, we investigate the relationship that may exist between mutual fund size and performance. More particularly, we test whether differences in assets under management can explain differences in performance. Several papers have already investigated the existence of a potential linear relationship between fund size and performance. Their results are ambiguous as they display conflicting conclusions. For instance, Chen *et al* (2004) and Yan (2008) find that bigger funds tend to underperform smaller ones. On the other hand, Liang (1999) and Amenc *et al* (2004) find a positive relationship between hedge fund size and performance, whereas Clark (2003) and Gregoriou and Rouah (2003) conclude to an insignificant link between both variables. Ding *et al* (2009) show that the direction of the relationship depends on the performance measure used.

In this section, we investigate the potential existence of a linear relationship between size and performance focusing on mutual funds. We use several measures to test the robustness of the results.

Methodology

We extend the methodology used by Ammann and Moerth (2005) and Xiong *et al* (2009)[2] to determine the relation between fund size and performance by using additional performance measures. Besides the Sharpe ratio, we make use of two performance measures on the basis of a single factor model Capital Asset Pricing Model (CAPM), Jensen's α and Treynor ratio, as well as of two performance measures on the basis of a multifactor model (Fama-French model augmented with the Carhart momentum factor), α and one of the performance ratios proposed by Bodson *et al* (2010). More particularly, we use their second ratio (ratio2) that we rename BCH ratio (based on the authors' names) for reading simplicity and clarification. To see whether there is a relation between mutual fund size and performance, we first sort mutual funds according to the size of their total net assets and group mutual funds in percentiles with their corresponding average size and weighted (by total net asset values) average return. We repeat this procedure for each month so as to obtain 100 time series of monthly average sizes and returns on which performance measures can be calculated. For each percentile, we compute the corresponding Sharpe ratio as

$$SR_i = \frac{E[R_{it} - rf_t]}{\sqrt{\mathrm{Var}[R_{it} - rf_t]}} \qquad (1)$$

where R_{it} is the return of percentile i at time t and rf_t the risk free rate at time t.

Single factor model-based performance measures are obtained from the following empirical regression (CAPM):

$$R_{it} - rf_t = \alpha_i + \beta_i(R_{Mt} - rf_t) + \varepsilon_{it} \quad (2)$$

where $(R_{Mt} - rf_t)$ is the market premium and α_i is the Jensen's α of percentile i.

The Treynor ratio is computed as

$$TR_i = \frac{E[R_{it} - rf_t]}{\beta_i} \quad (3)$$

For the multifactor approach based on the aforementioned four-factor model, we use the following regression:

$$R_{it} - rf_t = \alpha_i^{\text{multi}} + \sum_{k=1}^{4} \beta_{ik} F_k + \varepsilon_{it} \quad (4)$$

where F_k is the kth factor and α_i^{multi} the multifactor model α.

The second multifactor model-based performance measure is then computed as

$$BCH_i = E[R_{it} - rf_t] \frac{\text{Var}[R_{it} - rf_t]}{\text{Var}[\varepsilon_{it}]} \quad (5)$$

The next step consists in determining whether there exist a relation between mutual fund performance and size is to cross-sectionally regress each performance measures on the average percentile size. The regression is

$$\text{Perf Measure}_i = \alpha + \beta \log(\text{assets}_i) + \varepsilon_i \quad (6)$$

Results

Cross-sectional regressions results are reported in Table 3. The results from the linear regression provide no strong evidence of a linear relation between mutual fund performance and size. Only with the Treynor ratio and BCH ratio as risk-adjusted performance measures is the coefficient related to fund size significant. These results are consistent with Ding *et al* (2009), who find that the direction of the linear relationship may be different from one performance measure to another. We can notice that the size coefficient is negative for the Sharpe ratio, the single-factor α and the Treynor ratio and significant only for the Treynor ratio (at the 10 per cent level). On the other hand, both measures based on a multi-factor model display a positive coefficient although it is significant only for BCH ratio. We can also observe that the (adjusted) coefficient of determination is relatively low for all performance measures and the highest for the BCH ratio.

LINEAR OR QUADRATIC RELATIONSHIP?

Results from the linear regression do not enable us to capture potential non-linearities in the relationship between mutual fund size and performance. The possibility of a non-linear link between size and performance has already been highlighted by Hedges (2004), Ammann and Moerth (2005), Getmansky (2004) and Xiong *et al* (2009) in the hedge fund context. Consequently, this section

Table 3: Regression results: Linear regression

	Sharpe ratio	α	*Treynor ratio*	α *multi*	*BCH ratio*
log(assets)	−0.00113	−0.00014	−0.00020*	0.00008	0.00128***
	(0.00118)	(0.00009)	(0.00010)	(0.00008)	(0.00043)
Cst	0.04966***	0.00316***	0.00353***	0.00096**	0.00944***
	(0.00640)	(0.00048)	(0.00054)	(0.00041)	(0.00232)
R^2	0.0092	0.0229	0.0383	0.0103	0.0828
Adjusted R^2	−0.0009	0.0130	0.0285	0.0002	0.0735

***, ** and * respectively mean significance at the 1, 5 and 10% levels.
Notes: Mutual funds are sorted by size each month and grouped into percentiles according to their size. Risk-adjusted performance of percentiles is regressed on the logarithm of percentile average size. Standard errors are reported between parentheses.

investigates whether there may also exist non-linearities in the relation between size and performance for mutual funds.

Methodology

We use the same methodology as for the linear regression in terms of performance measures and percentiles. The difference lies in the cross-sectional regression that we perform. Instead of regressing percentile performance on the logarithm of average assets under management only, we add to the regression the square of the logarithm of average assets under management:

$$\text{Perf Measure}_i = \alpha + \beta_1 \log(\text{assets}_i) + \beta_2 \log(\text{assets}_i)^2 + \varepsilon_i \quad (7)$$

This enables us to test for the existence of a quadratic relationship between mutual fund size and performance. If the relation is concave, we can conclude to the existence of an intermediary (medium size) optimal size regarding performance. On the other hand, if the relation is convex, optimum is a corner solution meaning that either small or big funds are performance maximizer. In this case, we can define a medium size for which performance is minimized. Eventually, we might not find significant results regarding the quadratic term.

Results

Results of the quadratic regression are reported in Figures 2 to 6 for respectively the Sharpe ratio, the α, the Treynor ratio, the multi-factor α and the BCH ratio. We can

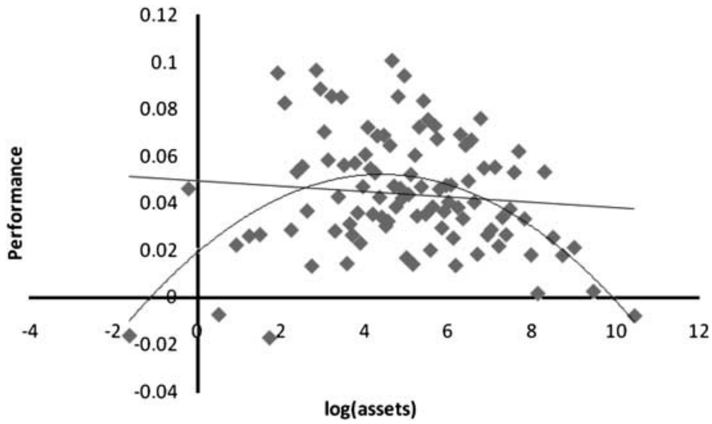

Figure 2: Sharpe ratio and asset size.

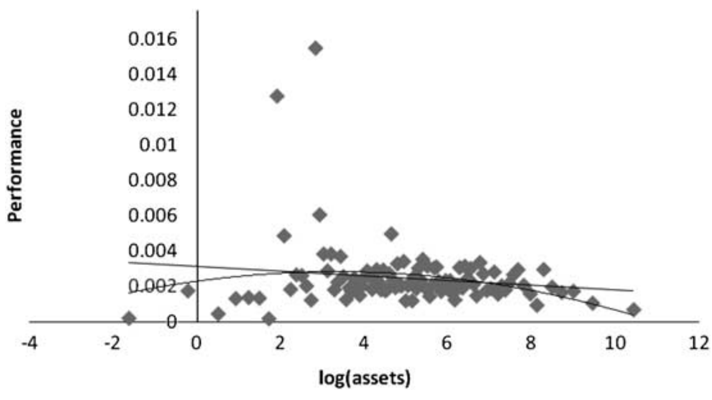

Figure 3: Alpha and asset size.

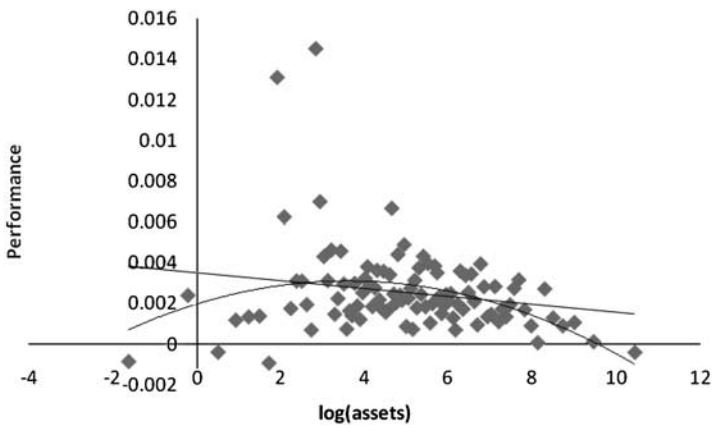

Figure 4: Treynor ratio and asset size.

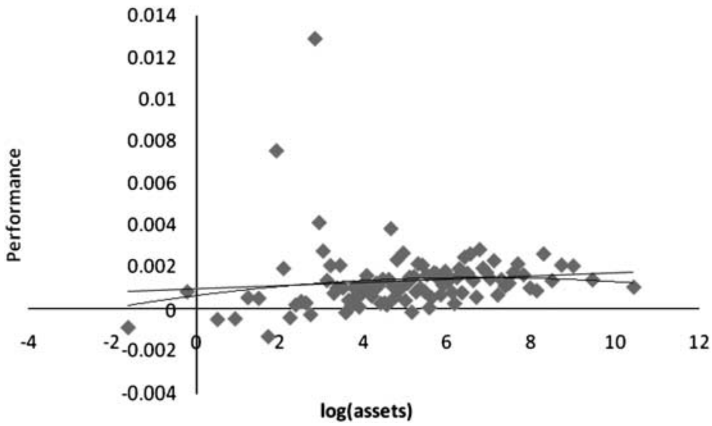

Figure 5: Multi-factor α and asset size.

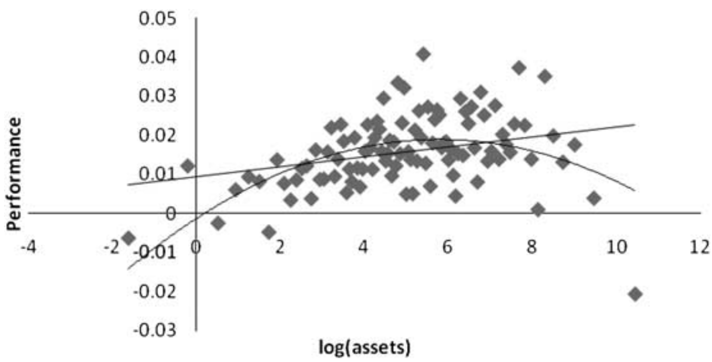

Figure 6: BCH ratio and asset size.

notice that the results are different from the linear regression. Indeed, all performance measures display the same sign on both coefficients (first and second orders). In addition, we can observe that the quadratic regression is significant for all measures except for the αs (both single and multi-factor). These results give strong indications that the relation between mutual fund size and performance may be quadratic rather

Table 4: Quadratic regression results

	Sharpe ratio	α	*Treynor ratio*	α *multi*	*BCH ratio*
log(assets)	0.01507*** (0.00325)	0.00032 (0.00027)	0.00063** (0.00030)	0.00026 (0.00024)	0.00698*** (0.00119)
log(assets)^2	−0.00171*** (0.00036)	−0.00005* (0.00003)	−0.00009*** (0.00003)	−0.00002 (0.00002)	−0.00060*** (0.00012)
Cst	0.01925** (0.00809)	0.00229*** (0.00068)	0.00198*** (0.00074)	0.00063 (0.00059)	−0.00127 (0.00297)
R^2	0.2299	0.0535	0.1170	0.0169	0.2744
Adjusted R^2	0.2140	0.0340	0.0988	−0.0034	0.2594
Inferred optimal size (million USD)	81.09	27.95	36.66	838.47	324.93

***, ** and *respectively mean significance at the 1, 5 and 10 per cent levels. Standard errors are reported between brackets.
Notes: Mutual funds are sorted by size each month and grouped into percentiles according to their size. Risk adjusted performance of percentiles are regressed on the logarithm of percentile average size and the squared logarithm of percentile average size.

than linear. This conclusion is also strengthened by the increase in adjusted coefficients of determination as we move from a linear to a quadratic regression (except in the case of the single and multi-factor αs). The consistent negative coefficient on the quadratic term implies that the relationship between mutual fund performance and size is concave. This suggests that there exists an intermediary optimal size (between small and big), which maximizes mutual fund performance (Table 4).

Depending on the performance measure used, the optimal average fund size varies from 27.95 to 838.47 million USD. However, the two extreme sizes come from the α and the multi-factor α whose results are not sufficiently significant. We may then conclude that the optimal average size lies (significantly) between 36.66 and 324.93 million USD.

So far, the most commonly used performance measure in a multi-factor context is undoubtedly the α. Very few multi-factor performance measures[3] have been proposed in the literature and none of those has been able to supplant α as the dominant measure in this context. BCH ratio has been shown to outperform the α in terms of stability and persistence by Bodson *et al* (2010). From our multi-factor analysis, we can also notice that BCH ratio seems to outperform (based on the adjusted R^2) the multi-factor α in terms of information regarding the relation between mutual fund size and performance. Indeed, as already mentioned, the multi-factor α does not provide significant results regarding size and performance contrarily to the results of two other commonly used performance measures (that is, Sharpe and Treynor ratios). On the other hand, BCH ratio results are in line (that is, a significant concave quadratic function) with Sharpe and Treynor ratios. In addition, BCH ratio exhibits a higher (adjusted) coefficient of determination with respect to all other performance measures used (and especially to the multi-factor α). On the basis of our analysis, BCH ratio seems to be the most informative performance measure among single- and multi-factor performance measures. As a consequence, BCH ratio may appear as an interesting alternative measure to the α in a multi-factor framework.

Conclusion

In this article, we investigate the potential relationship between mutual fund performance and size. The existing literature on the topic does not provide clear-cut results about the form and the direction of this relationship for hedge funds, as well as for mutual funds. The link is sometimes found to be positive, negative, concave or even inexistent. These results may also depend on the kind of funds analyzed, their strategy or the performance measure used. In this context, we propose a general framework to study the relationship between performance and size for mutual funds. We investigate both linear and quadratic relationships. In addition, we use several commonly used performance measures (Sharpe ratio, Treynor ratio, α single and α multi-factor), as well as a new multi-factor model-based performance measure (BCH ratio). Our results suggest that there exist a relationship between mutual fund performance and size and that it is quadratic and concave. Only for the α both single- and multi-factor is the relationship insignificant. This implies that there exists an intermediate optimal mutual fund size with respect to adjusted performance optimization.

NOTES

1. Factors, as well as the risk free rate, are retrieved from the Kenneth French's website: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.
2. Ammann and Moerth (2005) and Xiong *et al* (2009) study the relation between performance and size in the case of hedge funds.
3. We can mention among others the Generalized Treynor ratio (Hübner (2005)).

REFERENCES

Agarwal, V., Daniel, N. and Naik, N. (2004) Flows, Performance, and Managerial Incentives in Hedge Funds. Center for Financial Research Working Paper.

Amenc, N., Curtis, S. and Martellini, L. (2004) The Alpha and Omega of Hedge Fund Performance Measurement. EDHEC Working Paper.

Ammann, M. and Moerth, P. (2005) Impact of fund size on hedge fund performance. *Journal of Asset Management* 6(3): 219–238.

Bodson, L., Cavenaile, L. and Hübner, G. (2010) Normalized risk-adjusted performance measures based on multifactor models. Doctoral Thesis Collection. *Essays in Empirical Finance, Portfolio Risk and Performance Management*. Liége, Belgium: University of Liège, pp. 23–46.

Carhart, M. (1997) On persistence in mutual fund performance. *Journal of Finance* 52(1): 57–82.

Chen, J., Hong, H., Huang, M. and Kubik, J. (2004) Does fund size erode mutual fund performance? The role of liquidity and organization. *American Economic Review* 94(5): 1276–1302.

Clark, A. (2003) Does fund size affect performance? Lipper Research Study.

Ding, B., Shawky, H. and Tian, J. (2009) Liquidity shocks, size and the relative performance of hedge fund strategies. *Journal of Banking and Finance* 33(5): 883–891.

Fama, E. and French, K. (1992) The cross-section of expected stock returns. *Journal of Finance* 47(2): 427–465.

Fuss, R., Kaiser, D. and Strittmatter, A. (2009) Measuring funds of hedge funds performance using quantile regressions: Do experience and size matter? *Journal of Alternative Investments* 12(2): 41–53.

Getmansky, M. (2004) The Life Cycle of Hedge Funds: Fund Flows, Size and Performance. MIT Working Paper.

Gregoriou, G. and Rouah, F. (2003) Large versus small hedge funds: Does size affect performance? *Journal of Alternative Investments* 5(3): 75–77.

Guidotti, I. (2009) Tradeoff between liquidity, size and performance. *Hedge Fund Journal*.

Hedges, J. (2004) Size vs. performance in the Hedge fund industry. *Journal of Financial Transformation* 10: 14–17.

Herzberg, M. and Mozes, H. (2003) The persistence of hedge fund risk: Evidence and implications for investors. *Journal of Alternative Investments* 6(2): 22–42.

Hübner, G. (2005) The generalized Treynor ratio. *Review of Finance* 9(3): 415–435.

Indro, D., Jiang, C., Hu, M. and Lee, W. (1999) Mutual fund performance: Does fund size matter. *Financial Analysts Journal* 55(3): 74–87.

Latzko, D. (1999) Economies of scale in mutual fund administration. *Journal of Financial Research* 22(3): 331–339.

Liang, B. (1999) On the performance of hedge funds. *Financial Analysts Journal* 55(4): 72–85.

Perold, A. and Salomon, R. (1991) The right amount of assets under management. *Financial Analysts Journal* 47(3): 31–39.

Xiong, J., Idzorek, T., Chen, P. and Ibbotson, R. (2009) Impact of size and flows on performance for funds of hedge funds. *Journal of Portfolio Management* 35(2): 118–130.

Yan, X. (2008) Liquidity, investment style, and the relation between fund size and fund performance. *Journal of Financial and Quantitative Analysis* 43(3): 741–768.

Zera, S. and Madura, J. (2001) The empirical relationship between mutual fund size and operational efficiency. *Applied Financial Economics* 11(3): 243–251.