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Efficiency of mutual funds and portfolio performance measurement: A non-parametric approach

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Abstract

In finance, portfolio performance assessment is an important area of research. The two popular indices of performance are the Jensen's alpha and the Sharpe index. However there are a number of shortcomings of the above measures that have been highlighted in the literature. We propose a new measure of performance that seeks to address the limitations of the earlier indices. The new index is calculated by employing a well known method in operations research called data envelopment analysis. We show the benefits of the proposed approach and assess the performance of mutual funds. We compare the results with traditional indices of performance. An interesting result we obtain is that the mutual funds are all approximately mean-variance efficient. © 1997 Elsevier Science B.V.

1. Introduction

There are two major indices that are often used in the assessment of portfolio performance: Jensen's alpha (Jensen, 1968) and the Sharpe index (Sharpe, 1966). Researchers have critically examined both these measures and show that these indices, though potentially very useful, do not address a number of issues. The three major issues in portfolio performance evaluation are the appropriate benchmark to be used for comparison, the role of market timing and the endogeneity of transaction costs.

In this paper, we propose a new index to measure portfolio performance that addresses some of the criticisms of the above indices. We propose a relative measure of performance that does not require the specification of a benchmark and also incorporates transaction costs. We employ a technique called data envelopment analysis (DEA), that is widely employed in operations research to compute relative measures of efficiency. We call our new index the DEA portfolio efficiency index (DPEI). We then compare the DPEI with the traditional Jensen's alpha and the Sharpe index, within the context of mutual funds' performance assessment. We discuss the relative merits and limitations of the proposed index. We also attempt to explain the variation in mean efficiency scores across different categories of mutual funds.

The issues of benchmarks and market timing have been extensively discussed in the finance literature (Grinblatt and Titman, 1989, 1993). Jensen's alpha has been the focus of discussion because it is the most widely used index of performance among aca-

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demics and practitioners. It is defined as the difference between the actual portfolio return and the estimated benchmark return. The benchmark could be based on either the CAPM (capital asset pricing model) or the APT (arbitrage pricing theory) model. Researchers have argued that the Jensen's alpha is sensitive to the choice of the benchmark model that is employed for comparison (Roll, 1978; Green, 1986; Lehman and Modest, 1987; Elton et al., 1993; Choi, 1995). For instance, one would obtain different indices based on whether they employed the CAPM or the APT model as a benchmark.

In addition, researchers have argued that the estimation of Jensen's alpha may be biased due to market timing, which is the ability of fund managers to systematically change the target risk of the fund (Jensen, 1972; Admati and Ross, 1985; Dybvig and Ross, 1985). When portfolio managers change the target beta for the fund by moving money among different investments, estimation bias will be introduced into the benchmark model because it assumes a constant beta coefficient over the period under study.

The other commonly used yardstick of portfolio performance, the Sharpe index, is defined as the ratio of the excess return of the portfolio (over the risk free return) to the standard deviation. Relative to Jensen's alpha, this measure avoids the problem of the specification of the benchmark model. However, even this index does not take into account the transaction costs or the expenses associated with the purchase and sale of assets. Funds usually charge loads or other fees to recover the costs of conducting financial transactions on behalf of the investor. The inclusion of transaction costs in portfolio performance measurement is important because researchers have established a connection between the two variables (Grossman, 1976; Grossman and Stiglitz, 1980; Ippolito, 1989; Elton et al., 1993). The main argument is that if the collection and usage of information is costly, informed investors should obtain higher returns relative to the uninformed investors. Also, Grinblatt and Titman (1989) argue that if portfolio managers have superior ability, they may be able to expropriate the economic rents by charging higher fees. Thus, one would expect to see a relationship between the transaction costs and the return. Also, from an investor's point of view, any index of performance should consider transaction costs as well.

In an attempt to circumvent the benchmark issue, Grinblatt and Titman (1993) propose a new measure of portfolio performance that does not require the use of a benchmark portfolio. They measure the correlation between the return and the changes in portfolio weights and use the correlation as an indicator of management performance. They apply their method in the context of evaluation of the performance of mutual funds. However, their proposed measure does not account for transaction costs.

We develop our index of performance by modifying the basic idea employed in Sharpe index to incorporate transaction costs. The Sharpe measure is defined as R/σ where R is the difference between the actual return and the risk free return and σ is the standard deviation of the return. Hence, the index captures the risk premium per unit of risk. In order to account for transaction costs, we define an index I for each mutual fund as

$$I = \frac{R}{\sum_i w_i X_i + v\sigma},$$

where X_i refers to transaction costs such as expense ratio, loads and turnover (see Table 1 in Section 3 for definitions of the variables). The weights w_i and v are associated with the variables X_i and σ, respectively. The ratio 'I' defines a measure of the excess returns that a fund obtains for a given level of risk and transaction cost. In other words, 'I' represents the surplus return over and above the market return that is obtained by a fund after controlling for the level of risk of the investment and the expenses incurred in conducting the transactions. This is consistent with the measures of efficiency that are employed in production economics where the ratio of output to inputs is an indicator of how well the manager utilizes the resources to obtain the maximum level of output.

In order to determine the weights w_i and v, we can employ a parametric approach and specify a functional form for the correspondence between return and transactions costs and standard deviation. Then ordinary least squares or nonlinear methods can be employed to estimate the weights. However, Varian (1990) advocates the use of a nonparametric approach to measure optimal behavior of investors or consumers. He argues that the traditional recourse to parametric specifications and testing for the significance of the estimates puts a great emphasis on the statistical significance and ignores the issue of economic significance. Varian argues that the economic significance of a departure from optimizing behavior is more relevant. Given a set of data (prices, demands and output), Varian proposes measures based on 'residuals' which measure the difference between the ratios of outputs and inputs constructed from the data and 1 (the maximum value of efficiency). Seiford and Thrall (1990) show the connection between Varian's measures and efficiency scores obtained from data envelopment analysis. In this spirit, we employ data envelopment analysis (DEA), a nonparametric analysis technique which was proposed by Charnes et al. (1978) to measure the performance of educational institutions. DEA is a linear programming formulation that defines a correspondence between multiple inputs and multiple outputs.

Banker and Maindiratta (1986) have shown that DEA offers certain advantages over parametric methods. First, DEA does not impose the assumption of any functional form on the input–output correspondence. This feature is useful for cases in which the relationship is not known or specified by theory. The minimum assumptions needed for DEA are monotonicity and convexity of the efficient frontier (Banker et al., 1984). Second, DEA measures the efficiency with respect to the Pareto-efficient frontier which measures the best performance that can be practically achieved whereas parametric methods (such as those based on regression) estimate efficiency relative to the average performance. Third, DEA permits the calculation of an efficiency index for each mutual fund, while the parametric approach provides statistical averages. Finally, one can use DEA to not only identify the inefficient firms, but also to estimate the magnitude of inefficiency. Such an analysis would suggest ways in which the inefficient firm can be made efficient.

Thus we see that DEA is an extremely useful technique for measuring efficiency when there is little a priori information about the functional form of the relationship. Researchers have employed DEA for the evaluation of educational programs (Charnes et al., 1978), hospitals (Banker et al., 1984), banks (Sherman, 1984) and retail sales units (Mahajan, 1991). To the best of our knowledge, our paper represents the first attempt to measure financial performance of mutual funds using DEA.

For our purposes, the advantages of data envelopment analysis regarding the three issues in portfolio performance evaluation are summarized below.

(1) DEA is a non-parametric analysis that does not require any theoretical models (CAPM or APT) as measurement benchmarks. Instead DEA measures how well a fund performs relative to the best set of funds within the declared objective category.

(2) It can address the problem of endogeneity of transaction costs (i.e. market efficiency) by considering the transaction costs such as expense ratio, turnover and loads as well as the return simultaneously in the analysis. In fact the model is flexible and can evaluate performance on a number of outputs and inputs simultaneously. For instance, if managers were responsible for both returns and size of the asset base, their performance can be evaluated using DEA.

(3) It is possible to discuss relative importance among the inputs (transaction costs); for example, we can observe the marginal contribution of each input in affecting returns. This observation allows us to discuss optimal resource allocation to generate portfolio return and the implications for portfolio measurement.

We apply the DEA analysis to mutual fund industry and compare the results with the traditional measures such as Jensen's alpha. It is easy to conceptualize managerial efficiency that DEA measures in terms of output–input ratios in the manufacturing industry. In portfolio management, performance is evaluated in terms of benefit to cost ratios. That is, consumers desire a fund that maximizes the benefit (return) and minimizes the cost (expense ratio, turnover and loads — refer to Table 1 for definitions of these terms) at the same time. This framework is consistent with the current finance literature examining the issues of market efficiency regarding transaction costs in mutual fund industry. Thus we see that DEA is an appropriate technique to apply for evaluation of portfolios.

We employ the new DEA index to study issues in finance literature. An interesting result that we obtain indicates that the mutual funds are all approximately mean variance efficient. This provides further strong empirical support to the well known mean variance theory of Markowitz, and Sharpe–Lintner. According to the theory, market portfolios are efficient in the sense that they have the maximum expected return for a given level of variance.

We organize the rest of the paper as follows. Section 2 introduces the DEA method and its connection to the Sharpe index of performance measure. Section 3 describes the empirical analysis and the data. Section 4 reports the performance results of mutual funds in each investment objective category. We compare the traditional measurement indices to our DEA based index. In Section 5, we conclude and provide directions for future research.

2. DEA portfolio efficiency index (DPEI)

The Sharpe index measure was proposed as an alternative measure to the Jensen index by Sharpe (1966). The Sharpe index is obtained as stated above by dividing the excess return on a portfolio by the standard deviation. It therefore measures the risk premium earned per unit of risk taken. Roll (1978) argues that the Jensen index is very sensitive to the choice of the market index used and may not be an appropriate measure of the quality of managers running the portfolio. The Sharpe index is much more robust to the market index problem because it uses *standard deviation* as a risk measure, not *beta*. However, the market index problem is not totally eliminated because the final Sharpe index of a portfolio is compared to the Sharpe index of the market index. The 'DEA portfolio efficiency index' we propose compares the index of each portfolio to the best portfolio available in the class. Given the transaction cost structure (e.g. expense ratio, turnover and loads) and risk taken, we evaluate which fund generates the highest return in the same class.

As in the Sharpe index, we consider only one output, that is return. It does not matter whether we consider excess return (actual return − risk free return) or just actual return as DEA is a relative measure of performance and the risk free return is a constant that is common across all categories of funds. In order to generate the return, managers incur transaction costs and pass the costs on to the investors. Some costs such as expense ratio include management fees, marketing expenses and other operational expenses. In addition mutual funds charge loads for certain funds. These loads may be charged at the beginning when the customer invests or they may be deferred till the time the customer withdraws his funds. Another measure of transaction costs is the turnover which captures the trading activity of the manager. The greater the turnover, the greater is the transaction cost because of the increase in the number of trades. So an investor is interested in finding the return that the fund earns net of transaction costs at a given level of risk. We employ standard deviation as the measure of risk analogous to the Sharpe index. Thus in our DEA model we have one output and four inputs: expense ratio, load, turnover and standard deviation.

2.1. Data envelopment analysis

We briefly describe the DEA formulation as given in Charnes et al. (1978). The simple DEA program is formulated as a fractional programming problem and is then reduced to a linear programming problem that is easy to compute. In general, the program maximizes the ratio of the weighted average of the multiple outputs to the weighted average of the multiple inputs. In our case, we have only one output, that is, return R.Maximize

$$\mathrm{DPEI} = \frac{R_0}{\sum_{i=1}^{I} w_i x_{i0} + v\sigma_0}$$

subject to

$$\frac{R_j}{\sum_{i=1}^{I} w_i x_{ij} + v\sigma_j} \le 1 \quad j = 1, \ldots J$$

and w_i, $v \ge \varepsilon$, where: J = number of funds in the category, I = number of inputs, R_j = the value of the return for the jth fund, x_{ij} = the value of the ith transaction cost for the jth fund, ε = *fixed* as a *positive* valued non-Archimedean infinitesimal smaller than any positive real number [1] and w_i and v are weights given by the solution to the programming problem with the condition w_i, $v \geq \varepsilon$, restricting the solutions to positive values of these variables. The subscript 0 refers to a particular fund that is being evaluated. The above program finds the weights that maximize the ratio of the return to the weighted inputs of a fund subject to the condition that all such ratios of the funds are less than or equal to one. In that sense, DEA measures the efficiency of a fund in relation to that of the set of funds that use the same inputs to obtain the same outputs. DEA is able to segregate the efficient funds from the inefficient funds based on whether they lie on the Pareto-efficient frontier. The distance of a fund from the efficient frontier gives a measure of its relative inefficiency. The efficient frontier is piecewise linear and a fund is considered to be inefficient only in relation to the referent set of firms. A fund is said to be efficient if the value of the objective function is one and the slack variables are all zero.

Though we do not employ it here, DEA is flexible enough to control for factors that are beyond the manager's control before determining efficiency. The specification has also been extended to control for varying returns to scale by Banker and Thrall (1992). Also, refer to Cooper et al. (1996) for detailed discussions of uses of these concepts in DEA. The above program is then transformed into a linear programming problem that is easy to compute (Charnes et al., 1978).

The weights w_i and v obtained from solving the linear programming problem indicate the relative position of the fund in relation to the Pareto-efficient frontier. The value of the objective function is a measure of the relative efficiency of the fund and is constrained to lie between (0, 1). The slack variables, if non-zero, indicate the extent to which each

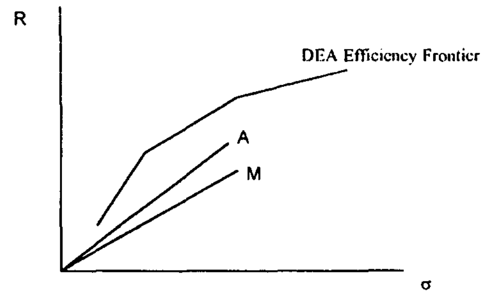

Fig. 1. Comparison between DEA efficiency frontier and Sharpe index. 'A' represents the mutual fund being evaluated. 'M' represents the market portfolio.

input can be reduced to achieve a relative efficiency of one. In other words, the slacks could indicate the magnitude of the reduction in transaction costs needed to place the particular fund on the efficiency frontier. We assume that such reductions are meaningful and implementable.

In order to get an intuitive understanding of the differences between DEA based index and the Sharpe index we show in Fig. 1 the correspondence between return and standard deviation. For this illustration, assume that there is only one input and one output. Sharpe index measures the slope of the line through the origin to the point that represents a particular fund's location on the R–σ plane. This is then compared to the slope of the market portfolio represented by point M. By using DEA, we fit a convex hull on the points that represents the various funds in a fund category. This convex hull is a piecewise linear frontier that represents the best achievable return for a given risk in a category. The relative efficiency of a fund is a measure of the distance from this practically achievable efficient frontier. Thus the benchmark in DPEI is the best performing set of funds in a category. Note that DEA permits an extension of the above model to many inputs and outputs thereby providing much more flexible tool for performance assessment. We now describe an application of the method using data on mutual funds.

3. Methodology and data description

3.1. Empirical analysis

We have access to cross sectional data collected by the reputed Morningstar, on 2083 mutual funds

[1] This closes the set so the use of 'max' in the objective function is legitimate. It is not necessary to specify the value of ε explicitly. This is handled by a two stage routine in most DEA computer codes by optimizing on θ in the primal (envelopment) model. With this value fixed, a second stage is then used to maximize the slacks. If any slacks are not zero, the associated w_i^* or v^* in the dual (multiplier) model will then also involve ε with these slacks values as coefficients. We thank the editor for pointing this out. See Cooper et al. (1996) and Arnold et al. (1996) for details.

Table 1
Mean characteristics of 731 funds on turnover, loads, expense ratio (excluding loads) and net asset value by investment objectives as of 1993

	Aggressive growth	Asset allocation	Equity income	Growth income	Income average	Balance	Growth	Total
Number of funds	46	47	48	184	29	63	314	731
Net asset value (million)	312.52	428.04	735.65	863.02	109.55	771.65	594.43	544.98
Expense ratio [a] (%)	1.72	1.44	1.18	1.29	1.07	1.13	1.30	1.30
Loads [b] (%)	2.94	2.93	2.69	2.63	2.40	3.13	2.86	2.80
Fund turnover [c] (%)	135.0	106.21	51.75	65.84	79.28	84.44	85.12	86.81

[a] Expense ratio refers to the costs incurred by the mutual fund in operating the portfolio, including administrative expenses andadvisory fees paid to the investment manager, usually expressed as a percent of total assets under management.
[b] Turnover is the less of monthly purchases or sales in the fund during the month divided by average net assets value.
[c] Loads are sales charge or redemption fees incurred when investors purchase and sell the shares.

for the third quarter of 1993. The electronic version of the data can be easily purchased from Morningstar. In the first phase of the empirical analysis, we demonstrate the DEA procedure and assess the validity of the DPEI measure by comparing it with traditional measures of performance. For this purpose, we picked seven categories of mutual funds which were used in earlier studies (Grinblatt and Titman, 1989, 1993). These categories are aggressive growth, asset allocation, equity-income, growth, growth-income, balanced and income. Each category has a stated objective which describes the manner in which the investments will be made. Thus, we had a total of 731 mutual funds in the above seven categories. For each of the funds, we have information on actual annual return, expense ratio, standard deviation, total load and turnover. We also have information on the Jensen's alpha and the Sharpe index. We computed return as the value of an investment of one dollar in a fund after a period of one year [2]. Further we examine the gross returns before any expenses are deducted. This is consistent with Jensen (1968) who suggests that in order to study the impact of transaction costs which may be an indication of superior management talent, one should look at gross returns [3]. Though there are a number of good software packages available for doing DEA, we developed and used our own code in Fortran using LINDO for solving the linear programming problem.

In the second part of the empirical analysis, we try to understand the variation in mean DPEI across categories of funds. For this purpose we use all 33 categories of funds (2083 observations) and compute the DPEI for each fund within each category. We undertake a regression analysis to test for the source of variation in mean DPEI across the 33 categories. The regression allows us to test whether performance is related to different types of transaction costs.

3.2. Description of data

In Table 1, we report the descriptive statistics for the seven categories of mutual funds. From a comparison of the summary data from Table 4 (Ippolito, 1989) we find that the net asset value more than quadrupled during last 20 years; Grinblatt and Titman (1989) report an average net asset value of the funds for about $113.8 million in 1974. After 20 years, the average NAV has increased to about $545 million, showing a continuous growth of this indus-

[2] Note that Thrall (1996) has shown that problems occur in the dual when the origin is shifted by adding or subtracting constants in the constraints of the primal model. Here we transform the actual return r to $R = 1 + r$ and we need to examine the effect of this transformation. We ran the DEA again with r as the output variable instead of R and found that the results did not change.

[3] Grinblatt and Titman (1989) use the portfolio holding of actual funds to compute gross returns.

Table 2
Summary statistics on the efficiency index and other indices by investment objectives

	Aggressive growth	Asset allocation	Equity income	Growth income	Income	Balance	Growth
DPEI:							
Mean	0.86	0.82	0.88	0.73	0.81	0.77	0.67
Standard deviation	0.14	0.16	0.12	0.16	0.17	0.16	0.15
Jensen index:							
Mean	6.16	3.37	3.70	1.13	7.82	3.01	2.04
Standard deviation	6.96	3.31	3.52	4.01	3.32	2.83	4.91
Sharpe index:							
Mean	6.22	7.43	6.74	5.14	9.77	6.20	5.26
Standard deviation	2.70	3.54	2.30	2.59	2.80	2.43	2.74
N	46	47	48	184	29	63	314

try. Ippolito (1989) reports turnover and expense ratios for the period 1965–1984. Turnover has drastically increased to 86.8% in 1993 from 63.4% in 1982–1984. However, the expense ratio has been very stable at 1.07–1.30% in 1993, which is similar to the expense ratio for the period 1965–1984. Very high turnover in the aggressive-growth and asset allocation funds indicates that there is a lot of trading activity in these funds. The average load charged is 2.80% and appears to be constant across categories.

4. Results

In Table 2, we provide the mean and the standard deviation of the efficiency index (DPEI) by investment objectives. We find managers in the aggressive growth, asset allocation, income and equity-income funds are relatively more efficient in utilizing resources, while the growth, balanced and growth-income funds show a lower efficiency index. Thompson et al. (1996) have shown that the identification of efficient and inefficient units is fairly robust to data sensitivity. Even when all the data are varied simultaneously by 15–20%, the DEA results do not change. To correct for presence of outliers one can use the chance constrained DEA approach (Land et al., 1993).

4.1. Validation of the DPEI measure

In order to check how the DPEI compares to existing indices such as Jensen's alpha and Sharpe index, we present the correlations of DPEI index with these measures in Table 3. We find that there is a positive correlation between the DPEI and the Jensen's alpha across all categories of funds. The correlations range between 0.29–0.52 and are statis-

Table 3
Correlation between the efficiency index and the Jensen, Sharpe index, M-rating and beta

	Aggressive growth	Asset allocation	Equity income	Growth income	Income	Balance	Growth
Jensen measure	0.29 *	0.42 *	0.52 *	0.34 *	0.45 *	0.44 *	0.38 *
Sharpe measure	0.28 *	0.60 *	0.68 *	0.42 *	0.80 *	0.47 *	0.42 *
M-rating	0.32 *	0.24	0.49 *	0.39 *	0.46 *	0.49 *	0.37 *
Beta	−0.09	−0.57 *	−0.62 *	−0.44 *	−0.47 *	−0.63 *	−0.45 *

tically significant. We obtain a similar result when we compare the DPEI with the Sharpe index. As expected, the correlations of DPEI with Sharpe index are higher than the correlations with Jensen's alpha. To further validate the measure we computed the correlation of DPEI with Morningstar ratings and beta which is another measure of the non-diversifiable risk of the fund. Morningstar ratings are derived by classifying the funds on their risk adjusted return performance. These ratings are widely reported in the financial magazines. There is a positive correlation with Morningstar ratings and there is a significant negative correlation between the DPEI and beta in all categories except for the aggressive growth fund, which indicates that high-risk funds are associated with low efficiency. The lack of a significant correlation between efficiency index and beta in aggressive growth funds can be attributed to a large variation in beta values in the sample. Using the DEA based index, we now proceed to examine issues in finance that have been the subject of debate (Section 4.3). We also examine the relationship between the DPEI and the cost variables more carefully and discuss the implications for the market efficiency of the mutual funds industry.

4.2. Analysis of slack variables

We can identify the source of inefficiency by examining the slacks of the cost variables. Table 4 shows the mean of the absolute slacks in panel A and the relative mean slacks (absolute mean slack in input/mean value of the inputs) in panel B. Using the relative slacks, we can compare the marginal impact of transaction costs on portfolio return across different categories of funds. That is, the slacks measure where the portfolio managers expend resources inefficiently. A striking result is that the risk (measured by standard deviation) has virtually no slacks throughout all investment categories. This is consistent with the notion that mutual funds are on average mean-variance efficient. Of the transaction costs, turnover and loads have larger slacks indicating that more managers are inefficient on these two dimensions. The asset allocation funds are the most inefficient in turnover. In other words, managers in the funds spend much more in turnover activity than any other fund managers. An interesting observation about expense ratios is that the income funds are the most inefficient in expense ratios although they have the lowest expense ratios among the all funds. This indicates the expense ratios on the income funds are relatively expensive. Similar argument can be made about the loads in that relative loads are the lowest for the equity income funds although the loads are about the same in absolute terms.

4.3. Expense ratio, loads, turnover and performance

Grossman (1976) and Grossman and Stiglitz (1980) argue that if collection and implementation of information is costly, informed investors should be

Table 4
Mean slacks in inputs: expense ratio, load, standard deviation and turnover by investment objectives

	Aggressive growth	Asset allocation	Equity income	Growth income	Income	Balance	Growth
Panel A: Absolute slacks							
Expense ratio	0.034	0.075	0.129	0.086	0.263	0.108	0.011
Loads	0.934	0.338	0.082	1.373	1.424	1.58	1.282
Turnover	22.34	43.58	9.41	14.10	11.53	13.42	17.13
Standard deviation	0.006	0.0	0.002	0.001	0.008	0.013	0.010
Panel B: Relative slacks (absolute slack/mean value of inputs)							
Expense ratio	0.011	0.052	0.110	0.067	0.245	0.095	0.008
Loads	0.318	0.116	0.030	0.522	0.593	0.505	0.448
Turnover	0.165	0.410	0.182	0.214	0.145	0.159	0.201
Standard deviation	0.000	0.000	0.001	0.000	0.005	0.006	0.003

Table 5
Regression results: Relationship between mean DPEI and mean transaction costs across 33 categories

Variables	Intercept	Expense ratio	Loads	Turnover	Standard deviation	R^2
	0.790	0.090	−0.0007	−0.0001	−0.0145	0.090
	(10.85)	(1.39)	(−0.031)	(−0.383)	(−1.00)	

t-values are in the parentheses.

compensated with higher returns for their investment than uninformed investors. Ippolito (1989) tests this idea using mutual fund data over a twenty year period from 1965 to 1984. In the paper, Ippolito tests whether funds with higher expense ratios, higher fees and higher turnover earn sufficiently higher returns to compensate for the extra cost of trading and research. The net excess returns on mutual fund are regressed on cost variables, controlling for market factors and loads. The estimated coefficient of the cost variables should be insignificantly different from zero if mutual funds use resources efficiently. Ippolito's result shows that the coefficients on the turnover, management fee and expense ratios are not significantly different from zero. These results suggest that funds with higher turnover, fees and expenses seem to earn risk-adjusted returns sufficient to offset the higher charges. The estimated coefficient on the load variable was significantly positive which means that load funds earn returns more than sufficient to cover the load charge.

Elton et al. (1993) re-examine the same issue using multiple benchmarks rather than a single benchmark as in Ippolito. They show that the Jensen alpha computed using a single index (e.g. S&P500 index) can be biased because it omits the effect on the Jensen alpha of the other important indices such as bond and small-firm index. Using multiple benchmarks, they obtain a result that conflicts with Ippolito's result: there is a statistically significant negative relationship between performance and expenses, suggesting that higher expenses are associated with poorer performance. They obtain a similar negative relationship for turnover and loads as well. The contradicting result is explained as a manifestation of the sensitivity of the Jensen's alpha to the benchmark models.

Our DPEI approach avoids the ad-hoc benchmark problem of the earlier indices. Instead, DEA compares each fund with the set of efficient portfolios most like the one being evaluated (Cooper et al., 1996). In order to test the relationship between performance and transaction costs, we regress the mean efficiency scores against the mean transaction costs. This cross category analysis would reveal the source of variation in mean DPEI. Our regression results are given in Table 5. We find that mean efficiency scores are not related to mean expense ratios, mean loads or mean turnover. All the coefficients are not significantly different from zero. This finding implies that higher transaction costs are not correlated with better efficiency scores (DPEIs). In other words, funds that charge a higher transaction cost do not more than compensate for the greater cost in terms of efficiency (DPEI). Our result is in contrast to Ippolito's study which finds positive coefficients for loads.

4.4. Net asset value and performance

Grinblatt and Titman (1989) examine the effect of size of the funds on performance. Small funds may have an advantage over large funds because trading can be done without affecting securities prices. On

Table 6
Correlation between mean DPEI and mean NAV across 10 categories

Funds	Balanced	Corp. general	Corp. high quality	Foreign	Growth-income	Gvt. treasury	Muni. state	Sp. unaligned	Sp. utility	World
	0.206	0.254	0.264	0.335	0.298	0.32	0.269	0.206	0.254	0.264

the other hand, small funds may face higher transaction costs due to economies of scale. They show that the mutual funds with the smallest net asset values have the highest transaction costs and performance. We examine the correlation between the mean DPEI for each category and the mean net asset value (NAV) across the 33 categories. The correlation is not significantly different from zero. This suggests that efficiency is not related to the size of the funds.

However, when we compute the correlation between NAV and the efficiency score within each of the 33 categories, we find ten categories where the correlation is significantly positive. These categories are given in Table 6. Therefore we find some evidence that larger funds may be more efficient. This may be due to the fact that they have lower transactions costs. However, more research needs to be done to explain why size of fund affects performance in certain categories but not in others.

5. Conclusion

We examine the market efficiency of the mutual fund industry by different investment objectives. We use a benefit/cost non-parametric analysis where a relationship between return (benefit) and expense ratio, turnover, risk, and loads (cost) is established. We develop a new measure of performance of mutual funds that has a number of advantages over traditional indices. The DEA portfolio efficiency index (DEPI) can be considered as a generalization of Sharpe index because when the transaction cost input variables are dropped, the index is conceptually equivalent to the Sharpe index.

The advantages of the DEA approach are that it avoids the benchmark problem that exists in the traditional methods using the Jensen index and identifies the source of inefficiency. A positive correlation between the DPEI and the Jensen's alpha measure indicates that the DPEI can be employed as an alternative measure of portfolio performance measure. We have shown that our measure of performance is consistent with traditional indices and offers much greater flexibility. There are no assumptions of the functional form imposed in DPEI. The specification allows us to incorporate transactions costs in the evaluation of funds in a meaningful manner. This is an exploratory study which proposes a new approach to assess portfolio performance and future work will examine the usefulness of the index.

Using the DEA approach, we find strong evidence that the mutual funds are all approximately mean-variance efficient. Thus using an alternate index, we find empirical support for the mean variance efficiency theory. We use the DEPI to examine issues in finance. We show that efficiency of mutual funds is not related to transaction costs and that larger funds are more efficient in some categories. Future research should examine the issue of scale effects in mutual funds.

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