

Manager Attributes and Fund Performance: Evidence from Taiwan

Jin-Li Hu,¹ Hsueh-E. Yu and Yi-Ting Wang

Abstract

This paper applies a four-stage data envelopment analysis (DEA) approach proposed by Fried et al. (1999) to measure the operational environment-adjusted efficiency of sixty mutual funds in Taiwan from 2006 to 2010. We adopt the approach for adjusting negative output as suggested by Lovell and Pastor (1995). In addition, the truncated regression model is used to estimate effects of environmental variables on input slacks in the second stage. The efficiency of funds initially lightly declined, rapidly rose during the financial crisis of 2008, and then gradually fell again. Manager attributes as well as fund characteristics significantly affect the performance of mutual funds. This research finds that the Balance fund performs better than the others and female managers perform more outstandingly than male managers both in cost control and risk management. Accordingly, firm size measured by the net asset value of funds has a positive impact on performance, but persistence, manager tenure, manager replacement, and funds under management all negatively influence management performance.

JEL classification numbers: C81, G29

Keywords: Data envelopment analysis, Truncated regression, Mutual fund, Manager attribute, Slack-based method

¹ Institute of Business and Management, National Chiao Tung University, 118,
Chung-Hsiao W. Rd., Sec. 1, Taipei City 100, Taiwan, e-mail: jinlihu@yahoo.com

1 Introduction

Taiwan's mutual fund industry started with only a few offered funds in the beginning and experienced extraordinary growth since its foundation in 1983 and deregulation in 2003. This was achieved by allowing new entrants into the financial market which is in line with the trends of globalization. According to data from the Taiwan Financial Supervisory Commission, the total number of mutual funds increased from 287 in 2000 to a peak of 550 in 2010. The total net asset value also increased from "NT\$10.767 trillion to NT\$18.958 trillion," but these data points dropped in 2008 due to the global recession. As Taiwan's finance markets climbed higher, mutual funds have become an increasingly convenient and preferred investment vehicle, with more employees and institutions taking responsibility for their retirement options, income generation and capital formation.

Due to the impact from the global financial crisis, one of the major challenges faced by the mutual fund industry is gradually seeing greater market risk under declining interest rates in recent years. For operating in a highly competitive environment, it is necessary that fund companies continuously launch many kinds of funds to attract investors with different risk preferences and various investment demands. However, it is not easy for an investor confronted by so many confusing options to choose appropriate funds and superior fund managers due to limited knowledge and information. Therefore, the identification of a superior performing fund is a critical study issue.

A large number of fund performance studies have been broadly presented over the past several decades, but the findings still remain controversial. Most evidence typically concentrates on a small set of factors and only considers a single characteristic of either fund-specific or manager attributes, such as fund size, fund category, manager tenure and age, and other factors. Additionally, it is very rare for studies to investigate manager gender and manager replacement issues.

Generally speaking, the abilities or the number of women in the workplace has been neglected for a long time especially in East Asia, despite the fact that female managers, mostly well educated and highly professional, have played an important role in Taiwan's financial market. Chen [1] addressed that female fund managers in Taiwan usually experience unfair treatment or discrimination in job promotion due to the stereotyped gender view regardless of how outstandingly they perform. Through a classroom experiment, Wann and Lobo [2] also found that females are more risk averse and have lower returns. Moreover, Niederle and Vesterlund [3] indicated that a gender gap cannot explain performance difference. However, this may be gradually changing as the number of female managers makes up 33.3% of our sample (higher than 11% in the U.S.). As Bliss and Potter [4] noted, one reason for the omission of gender in prior studies, such as those done by Golec [5] and Chevalier and Ellison [6], is due to the relatively small number of female managers. Therefore, our paper would examine the potential

gender views and number limitation in the female sample. In addition, there is very high managerial turnover among fund managers in Taiwan's mutual fund industry. A plausible reason for it is attributed to inducements from head-hunting companies and the stock-picking ability of managers [1]. Therefore, it seems reasonable that underperforming fund managers will be easily replaced under a lot of stress caused by dissatisfied investors and their own fund companies setting up market indices as performance benchmarks. On the other hand, fund managers are likely to be promoted to higher positions or are hired away by other fund companies providing better opportunities (salaries or benefits) as a result of their performance success. Therefore, this paper will incorporate two important manager characteristics in order to provide new insights into Taiwan's mutual fund industry.

Instead of using parametric approaches, such as those used by Sharpe [7], Treynor [8], Jensen [9], Fama and French [10], and Carhart [11], this paper applies a four-stage data envelopment analysis (DEA) suggested by Fried et al. [12] to evaluate the performances of mutual funds issued by Taiwan's securities investment trust companies. Murthi et al. [13] are the first to employ the DEA approach proposed by Charnes et al. [14] to assess fund performance and noted three main advantages. First, DEA non-parametric approach may avoid the disadvantages of benchmark errors and sampling bias in parametric method. Second, DEA can simultaneously take into account several inputs and thus consider different risk measures and investment costs [15]. Third, this method permits us to discuss optimal resource allocation to generate portfolio return. Besides, it also provide a more accurate performance measure by considering all the radio and non-radial slacks ,and allows to identify the source of the inefficiency. DEA model also proved that Sharpe and Treynor indices are special cases of a DEA-based index (e.g., [15] and [16]) and thus may usefully complement the traditional indices.

The remainder of this paper is organized as follows. Section 2 presents the previous literature and related variables or factors affecting fund performance. Section 3 discusses the four-stage DEA model. Section 4 interprets data and variables' descriptions. Section 5 discusses empirical results. Finally, Section 6 concludes this article and suggests some essential implications for both investors and fund companies among many types of mutual funds and fund managers.

2 Literature review

Murthi et al. [13] first attempted to measure the financial performance of 731 mutual funds using the expense ratio and standard deviation of return as input variables, with return as the output index through the DEA. The empirical results revealed strong evidence that the mutual funds are all approximately variance efficient and larger funds are more efficient in some categories. Sequentially, Basso and Funari [15], Sengupta and Zohar [17], Anderson et al. [18], Devancy

and Weber [19], and Choi [16] extended to add or supplement modified numerical indices to measure the mutual funds' performances, implying that investment costs are also important determinants of fund performance.

By using DEA, some studies in the literature compared the performances of various mutual funds, whereas others examined those of sole or specific mutual funds. For example, Murthi et al. [13] divided mutual funds into seven categories to evaluate efficiency. Anderson et al. [18] assessed the relative performances of real estate mutual funds for the period 1997-2001. Gregoriou et al. [20] examined the performances of eight hedge fund classifications during 1997-2001 and 1999-2001. Kumar et al. [21] found that the correlation between the ranking of hedge fund strategies based on the Sharpe ratio and the DEA models is very low.

An essential purpose of our article aims to analyze a fund's performance. To do so, we seek to identify what specific environmental factors representing mutual fund characteristics and manager attributes may link to performance. Fund characteristics measure investors' demand for a fund or fund categories as reflected in its adaptive abilities. Manager attributes signal the effect of manager experience and human capital as reflected in his/her asset management abilities. As shown below, we find that the results of previous studies are somewhat conflicting.

Chen et al. [22], Annaert et al. [23], and Hu and Chang [24] indicated that fund size is related to performance, whereas Carhart [11] and Prather et al. [25] reported a lack of any relation. Performance persistence is a topic of high concern by most investors in the mutual fund market. Numerous studies, including Hendricks et al. [26], Carhart [11], Annaert et al. [23], and Hu and Chang [24], have reported that a fund's performance is significant and positively related to its previous performance, supporting the winners' (losers') repeat hypothesis, while the work of Prather et al. [25] argued this view. Moreover, fund age may affect performance. Annaert et al. [23] suggested that a fund with a longer operational period has an advantage of the economies of experience; however, Hu and Chang [24] revealed a reverse finding. In addition to the fund factors above, fund types or investment objectives are occasionally regarded as control variables to analyze a fund's performance.

With regard to managers' attributes, Chevalier and Ellison [6], Prather et al. [25], and Hu and Chang [24] considered tenure as a measure of managers' managerial experience. Golec [5] proposed that a longer tenure implies that manager's abilities have been appreciated. Some evidence ([24] and [27]) addressed that a fund's performance increases with its managers' tenure, while others ([28], [29], and [30]) argued that the relation does not significantly exist. According to prior works including Golec [5], Chevalier and Ellison [6], Gottesman and Morey [31], and Hu and Chang [24], education backgrounds may reflect the professional knowledge affecting the managers' performance. If one considers fund managers as skilled professionals whose job involves collecting and analyzing relevant data, it seems to assume that education level may be positively associated with performance. The number of funds under management

also may have an impact on performance. Hu and Chang [24] and Prather et al. [25] reported that if a manager manages more than two funds, then the performance would decline.

The issue of manager replacement has been previously neglected in the studies of mutual fund performance. So far as we know, Khorana [32] first reported an inverse relation between the probability of fund manager replacement and past performance, evaluated by asset growth rate and portfolio returns. Chevalier and Ellison [6] also found the same result, but Chen [1] found that male outperforming managers with a specialty in finance and window dressing tactics are prone to have a longer spell time of job replacement by selecting 358 Taiwan fund managers as a sample from 2001 to 2005.

Despite the stereotypical viewpoints that women are more risk-averse than men in financial decision-making (e.g., [2], [33], [34], and [35]), not many previous studies have deeply explored the issue of gender performance differences. Barber and Odean [36], using 35,000 individual investor data for six years, focused on this topic and demonstrated that female investors perform better than male investors in the financial market. Bliss and Potter [4] closely studied the relationship between the gender of a fund manager and fund performance and found that women managers hold portfolios with marginally more risk than men and they outperform their male counterparts. Subsequently, Atkinson et al. [37] found no differences in fund performance and risk preference after controlling for wealth and knowledge differences between two asset managers. Chen [1] showed that Taiwan female fund managers who managed lower beta funds seem to be more conservative and their survival time is longer than that of male managers, while the performance differences are not as obvious.

3 Methodology

This paper employs the four-stage DEA model proposed by Fried et al [12] to analyze fund underperformance and to re-evaluate managerial performance, because the all-in-one-stage and the two-stage approaches cannot incorporate operating environmental factors, which may influence the ability of management to transform input to output into a measure of technical efficiency. Instead of using the Tobit regression, a truncated regression technique is adopted in stage 2, because this method generates a much lower estimation bias as well as higher inference-making abilities as Simar and Wilson [38] showed.

Due to the fact that one output variable has a negative value in this study, it is necessary to translate the values of corresponding variable because a negative value is not allowed by the DEA. Lovell and Pastor [39] proved that while an input variable having a negative value is translated, the output-oriented BCC model suggested by Banker et al. [40] carries unit invariant and translation invariant properties. In contrast, when an output variable which has a negative value is translated, the input-oriented BCC model carries unit invariant and

translation invariant properties. According to the results of this method, we apply the input-oriented BCC model to our study. The four stages are described below.

Stage 1: Using DEA for evaluating fund performance

According to the work by Fried et al. [12], the first stage the computes a DEA frontier by using the basic input and output variables based on the DEA model theory. The efficiency scores as well as input slacks are computed in this stage. This variable-returns-to-scale (VRS) model assumes that there are data on K inputs and M outputs for each I fund. The i -th fund is represented by the column vectors x_i and y_i , respectively. The $K \times I$ input matrix X and the $M \times I$ output matrix Y represent the data for all I funds. The following linear programming problem is now solved and efficiency scores are obtained by using an input-oriented VRS model.

$$\begin{aligned}
 & \text{Min}_{\theta, \lambda} \quad \theta \\
 & \text{s.t.} \quad -y_i + Y\lambda \geq 0 \\
 & \quad \quad \theta x_i - X\lambda \geq 0 \\
 & \quad \quad \sum_{i=1}^I \lambda_i = 1 \\
 & \quad \quad \lambda \geq 0
 \end{aligned} \tag{1}$$

where θ is a scalar and λ is an $I \times 1$ vector of constants. The value of θ is the efficiency score for the i th object, which is between 0 and 1. Note that the convexity constraint ($\sum \lambda_i = 1$) indicates that the projected point (for that fund) on the DEA frontier is a convex combination of observed funds. Therefore, we can compute and compare the efficiency scores among mutual funds.

Stage 2: Decomposing fund performance by truncated regression

The objective of this stage is to analyze fund underperformance through slack-based method (SBM) by using truncated regression, which is used to quantify the effect of external conditions on the excessive use of inputs. In this stage, the input slack and environmental influence factors are regarded as dependent variable factors and independent variables, respectively, and fund underperformance is regressed on the characteristics of the funds' and the managers' attributes.

The truncated regression equations are specified as follows:

$$S_j^k = f(Z_j^k; \beta_j; \varepsilon_j^k), \quad j = 1, \dots, N; \quad k = 1, \dots, K, \tag{2}$$

where S_j represents the total radial plus non-radial slack of input j based on the DEA results from stage 1; Z_j is a vector of variables characterizing operating environmental variables (fund characteristics and manager attributes)

for unit k that may affect the utilization of input; β_j is a vector of estimated coefficients; and ε_j is a disturbance term. This equation represents the variation in total measures of inefficiency attributable to environment factors outside the control of management.

Stage 3: Adjusting output

The main task of the third stage is to use the parameters estimated from the truncated regression to predict the total input slack for each input and for each unit on external factors.

$$\hat{S}_j^k = f(Z_j^k; \hat{\beta}_j), \quad j = 1, \dots, N; \quad k = 1, \dots, K, \quad (3)$$

In order to obtain the new pseudo data, these predictions are used to adjust the primary input items for each unit in light of the difference between the maximum predicted slack and the predicted slack. This paper adjusts downward the input item of funds, which have disadvantages from their relatively unfavorable environments. The formula is listed in equation (4):

$$x_j^{k\text{adj}} = x_j^k + [\max\{\hat{\beta}\} - Z_j^k \hat{\beta}], \quad j = 1, \dots, N; \quad k = 1, \dots, K, \quad (4)$$

where $x_j^{k\text{adj}}$ and x_j^k are the adjusted and original input values, respectively. The bracket on the right side puts all funds into a common environment, which is the best favorable set of external conditions. Therefore, mutual funds, which have disadvantages by their relatively unfavourable environments, will adjust downward by a relative amount.

Stage 4: Re-evaluating DEA with adjusted data

In the last stage of the model, we re-run the input-oriented VRS DEA with the adjusted data obtained from the third stage. Hence, the results of this stage are a DEA-based evaluation of environment-adjusted fund performance.

4 Data collection and variables' description

The mutual fund data used in this paper originate from the Taiwan Economic Journal (TEJ) database [41] and the FundDJ website [42] during the years 2006-2010. By using 2006 as the base year, all nominal variables have been transformed into real variables through GDP deflators. A dataset of 447 mutual funds is collected; however, only 300 funds (i.e., 60 funds per year) are used in this empirical application owing to one criterion. In order to examine the persistence in fund performance, we choose funds that have operated for longer than two years. In light of the demarcation of investment objective, the 300 funds feature three different categories composed of Balance, Technology and

Communication, and Growth funds.

Following previous works ([13], [17], and [24]), we select actual annual return as the sole output variable and choose expense ratio and standard deviation of return as input variables. The former is a proxy for risk and the latter is a proxy for costs. The relevant variables are defined as follows:

- (1) Expense ratio refers to management expense ratio plus custodian expense ratio at the end of the year. S.D. refers to the annualized S.D. of the daily return. The actual annual return refers to the fund return in the current year.
- (2) Total fund assets and net asset value refer to the proxies for fund size in some works (e.g., [1] and [24]).
- (3) Persistence refers to the annual return of the previous year. It measures performance persistence.
- (4) Age of fund represents the establishment duration of a fund and is calculated by using the fund inception date and the end of the year.
- (5) Fund categories are dummy variables which represent Tech & Com and Growth (Tech & Com =1, otherwise=0; Growth =1, otherwise =0).
- (6) Tenure represents the managers' experience measured by the number of months that a manager has had in his or her fund management career.
- (7) MBA and domestic/foreign degrees act as proxies for business management knowledge and education level which are also dummy variables (MBA = 1, otherwise =0; Domestic degree=1, Foreign degree=0).
- (8) Funds under management represent whether or not a manager simultaneously manages more than one fund in the end of each period.
- (9) Gender of the manager is also a dummy variable (male=1, female=0).
- (10) Replacement of manager is used to examine the turnover of managers for each fund in the sample period.

In Table 1 below, also noteworthy is that the average return of previous performance reaches 17.67%, and the average fund's age is 9.44 years. In the managers' attributes data, the average manager's tenure is 51.67 months (about 4.3 years), and the average funds under management and replacement of managers are 2.06 and 1.59, respectively. Compared to other countries (11% in the U.S.), female managers at 33.3% is surprisingly higher, attributable to their better education and high employment, but male managers still dominate the fund industry in Taiwan.

It should be noted that all the relations between input and output are tested through Pearson correlation analysis and reveal positive signs. In other words, the output will not decrease with an increase in an input, implying that the isotonic property is satisfied in this study.

Table 1: Descriptive Statistics for all Variables

Variable	N	Mean	S.D.	Min	Max
<i>Output</i>					
Actual annual return (%)	300	33.05	38.99	-20.90	111.65
<i>Input</i>					
Expense ratio (%)	300	0.13	0.02	0.07	0.18
Standard deviation (%)	300	1.10	0.34	0.33	1.72
<i>Fund Characteristics</i>					
Total fund assets	300	17.28	20.10	1.75	139.89
Net asset value	300	16.33	9.40	3.10	72.97
Persistence (%)	300	17.67	38.77	-55.44	111.65
Fund age (years)	300	9.44	3.91	2.12	22.73
<i>Manager attributes</i>					
Tenure (months)	300	51.67	31.71	2	139
MBA	300	0.77	0.42	0	1
Domestic/Foreign degree	300	0.77	0.42	0	1
Funds under management (number)	300	2.06	1.02	1	5
Gender	300	0.30	0.46	0	1
Manager replacement (number)	300	1.59	0.79	1	4

Note: The variables are listed by the categories of input, output, fund characteristics, and manager attributes.

5 Results and discussions

Stage 1: Valuating initial fund performance

In the first stage, the DEA is applied to calculate the 300 funds' performance during the period of 2006-2010. Table 2 summarizes the initial DEA results, displaying that the lowest and highest average efficiency score years are in 2008 (0.340) and in 2009 (0.768), respectively. It is noted that, hit by a worldwide recession, the average fund efficiency in 2008 severely declined to the lowest level; however, the average fund efficiency in 2009 promptly reached a peak. Accordingly, in 2009, the Tech & Com and Growth funds with higher efficiency scores (0.881, 0.902), significantly perform well than the Balance funds with a worse efficiency score (0.578). On the other hand, in 2008, Tech & Com and Growth funds scoring worse marks (0.156, 0.177) significantly underperform when compared to the Balance funds scoring the best efficiency marks (0.631).

Although parts of results are not shown, most of them also interestingly illustrate that higher risk funds like Growth and Tech & Com funds are relatively preferred by investors due to their potential for greater returns during the economic recovery period, while the low-risk and stable funds like Balance funds are widely chosen during the economic depression period.

Table 2: Results of the Initial DEA Stage (2006-2010)

	Sample Size	Efficiency Score	S.D.
Year 2006	60	0.623	0.271
Year 2007	60	0.594	0.277
Year 2008	60	0.340	0.256
Year 2009	60	0.768	0.197
Year 2010	60	0.636	0.227
Whole sample	300	0.592	0.283
Balance funds	115	0.623	0.236
Tech & Com ^a funds	180	0.555	0.310
Growth funds	42	0.651	0.285

NOTE: ^aTechnology and Communication funds.

Regarding the efficiency score among fund categories, the best, second best, and worst efficiency scores are Growth funds (0.651), Balance funds (0.623), and Tech & Com funds (0.555). As described in Table 3, technology and communication funds have a relatively larger expense slack (1.5096) and risk slack (0.5537), implying a waste of input resources or other inefficiencies.

Table 3: Average Slacks of Two Inputs from 2006 to 2010

	Expense Slack	Risk Slack (S.D.)
Balance funds	0.7785	0.0962
Tech & Com ^a funds	1.5096	0.5537
Growth funds	1.4832	0.5374
Total	1.2263	0.3764

NOTE: ^aTechnology and Communication funds.

Stage 2: Quantifying the effect of the external environmental factors

In the second stage, by using the truncated regression, two input slacks derived from stage 1 are regressed on fund characteristics and manager attribute variables, respectively.

Table 4 below presents the effects of fund and manager characteristics on underperformance (slack). Within fund characteristics, both models show that Growth funds and Tech & Com funds have significantly worse performances (larger slacks) than the reference, implying that Balance funds have better performance. As expected, after separately estimating the effects of expense slack and risk slack, this result is still similar to the work of Hu and Chang [24]. Perhaps owing to the impact of the 2008 global financial crisis, most fund managers or investors may prefer to choose Balance funds to avoid uncertain risk and to acquire relatively stable yields or returns. Additionally, model 2 reveals that the higher the previous performance is, the larger the risk slacks will be. This suggests that previous performances are significantly negatively associated with the performance of present risk management. This result might be due to the increase of return-fluctuating risk during the research time. In contrast to several works ([24] and [26]), this finding does not support the winners' repeat hypothesis, but does support the findings of Prather et al. [25]. Not surprisingly, the size of funds is positively related to performance, implying that as the net asset value of a successful fund increases, the fund's risk-taking abilities may improve. This means that fund companies with higher net asset value tend to outperform those with less net asset value.

For the manager attribute factors, in Model 1, the results compellingly indicate that the longer the manager has executed a fund's investing strategy and has managed its portfolio trading activities in his/her management career, the larger the slacks will be, suggesting that managers' tenure has a significant and negative effect on performances. In contrast with prior studies authored by Golec [5] and Hu and Chang [24], our results argue the experience hypothesis for two explanations. First, a long tenure manager may have a strong human network over time, but this also means that he (she) has few opportunities of seeking better employment. Second, new managers (short tenure) may put more effort in their work, because they seem to be easily fired for poor performance and because they have longer careers ahead of them as noted by Chevalier and Ellison [6].

Similar to the research by Bliss and Potter [4], our findings indicate that the manager's gender is strongly negatively related to two input slacks, inferring that female managers perform better than male managers on cost control (lower costs) and risk management as can be seen in the two models. This implies that females put more emphasis on expense and risk reduction in their trading activities or portfolio construction. Moreover, it also supports that female fund managers are more risk-averse than male managers in financial decision-making, consistent with the view by Powell and Ansic [33] as well as by Ammon and Bernasek [34], in which the performance differences between two groups are not discussed. In addition, we further find a significantly positive relation between gender and

performance, which compares to Chen [1] who reported that gender/performance differences are not quite evident among Taiwan fund managers. Wann and Lobo [2] showed that females are more risk averse, and therefore have lower returns. In comparison, our paper considers risk as an undesired input or object based on Murthi et al.'s [13] study, and hence high risk would not be beneficial to real performance or higher return.

Table 4: Estimation Results of the Truncated Regression

Independent variables	Dependent variables			
	Model 1 (Expense slack)		Model 2 (S.D. slack)	
Constant	1.0686***	(0.1010)	-0.1866***	(0.4739)
<i>Fund Characteristics</i>				
Total fund assets	-4.61E-07	(0.0010)	0.0018	(0.4044)
Net asset value	-0.0035	(0.0023)	-0.0226***	(0.0002)
Persistence	-0.0002	(0.0005)	0.0043***	(0.0002)
Age of fund	-0.0021	(0.0049)	0.0180	(0.1403)
Tech & Com ^a funds	0.5822***	(0.0380)	0.9717***	(0.0000)
Growth funds	0.4218***	(0.0451)	0.4850***	(0.0000)
<i>Manager attributes</i>				
Tenure	0.0013*	(0.0006)	0.0023	(0.1321)
MBA	-0.0473	(0.0424)	-0.1259	(0.1722)
Domestic academic degree	-0.02786	(0.0424)	-0.1149	(0.2076)
Funds under management	-0.01470	(0.0189)	-0.0437	(0.2979)
Gender of manager	-0.1300***	(0.0405)	-0.2762**	(0.0062)
Replacement of manager	-0.0409*	(0.0243)	-0.0772	(0.1740)
Log likelihood	-61.2453			
No. of Observations	300			

NOTE: ^a Technology and Communication funds.

Numbers in parentheses are standard errors.

* Significance at the 10% level;

** significance at the 5% level; and

*** significance at the 1% level.

Model 1 indicates that the higher the managerial turnover is, the better the performance will be, implying that a manager's replacement is positively correlated with cost management performance. This result displays a reverse pattern, different from previous research studies including Chen [1], Chevalier and Ellison [6], and Khorana [32]. One possible explanation is that an underperforming fund manager would perhaps be easily replaced on account of dissatisfied investors and their bosses, and hence the fund performances may improve due to the higher manager turnover.

Stage 3: Data adjustment

The parameter estimates derived from the truncated regression are used to adjust the initial dataset according to equation (4). The maximum predicted slack (least favorable external environment) is for the Tech and Com funds, whereas the minimum predicted slack (best favorable external environment) is for the Balance funds.

Stage 4: Constructing the efficiency frontier for pure performance

In the final stage, we re-run the DEA model with adjusted inputs and original output data to derive pure managerial performance. The new efficiency scores are obtained after removing the influence of external environmental factors. Table 5 compares the results of stages 1 and 4, revealing that the average efficiency score and the number of efficient funds decrease after controlling for environment variables. In addition, growth funds still have the highest efficiency score in stage 1. Most of the funds' scores are between 0.5-0.6, implying that few funds are especially outstanding. Therefore, the variations of inefficiency can be mostly explained by fund characteristics and manager attributes.

Table 5: Comparison of the results for Stages 1 and 4

	Stage 1	Stage 4
Balance funds	0.623	0.556
Tech & Com ^a funds	0.555	0.528
Growth funds	0.651	0.596
Average efficiency scores	0.592	0.546
Standard deviation of efficiency scores	0.283	0.277
Minimum of efficiency scores	0.000	0.000
Maximum of efficiency scores	1.000	1.000
Number of efficient funds	161	147

NOTE: ^a Technology and Communication funds.

6 Conclusions and suggestions

Through a non-parametric four-stage DEA model, this paper uses panel data during the period of 2006-2010 to analyze fund underperformance, and decomposed them into fund characteristics and manager attributes, as well as managerial inefficiency. On the whole, it is quite fascinating that Taiwan's fund efficiency fluctuates like a wave, initially lightly declining, then undergoing a quick recovery in 2009 from the global recession in 2008, and then gradually falling again during the period of 2006-2010.

Whether we examine them from expense or risk perspective, Balance funds perform better. Accordingly, the significantly negative relation between the persistence factor and performance does not support the winner hypothesis, suggesting that it would be better for investors to not chase the past performance of funds, because previous performance does not ensure future success. Accordingly, fund size has a positive impact on performance, noting that big funds get bigger due to the existence of economies of scale.

Within the manager category, fund performance is decreasing with the tenure of managers, inferring that old managers may not outperform as well as new managers. Despite being an unexpected result, it might be possible that short tenure managers work harder than long tenure managers because they may desire to advance their careers or are afraid of losing their jobs due to poor performances. Accordingly, it is quite interesting that the impact of manager replacement on performance is statistically significantly positive. In other words, performances may be improved, because managerial replacement may modify or alter a poor investment decision or inactive management style. Most notably, one contribution of this paper is that we find evidence of risk-taking differences as female managers are more risk-averse and perform more outstanding than male managers in cost (or expense) control as well as in risk management. The female managers' successes may be attributed to the abilities of beating the market by stock-picking, timing, and other factors. Perhaps gender does matter, implying that this finding may shed light on the mutual fund labor market for female managers.

Finally, we conclude with some suggestions from our findings for investors and fund companies. From the investor perspective, in addition to matching one's individual investment objectives, an investor may select funds with lower slacks or with higher performance from the fund and manager characteristics such as Balance funds, persistence, large size funds, short tenure managers, high manager replacement, and female managers. For instance, fund investors, rather than constructing a fund portfolio based on previous performance, should deliberately choose a good manager. Most importantly, investors should not hold on to the stereotypical view that female fund managers underperform when compared to male fund managers. This is due to their moderate female investment style, which is less extreme and more stable, and leads to a higher performance persistence. From the fund company's perspective, manager attributes should be of greater concern, because these factors are more controllable than fund characteristics.

Moreover, employing more female managers, providing incentive contracts or promotions to attract outstanding managers with stock picking abilities, and replacing poorly performing managers are all necessary actions for fund performance improvement.

Acknowledgements. Financial support from Taiwan's National Science Council (NSC100-2410-H-009-051) is gratefully acknowledged.

References

- [1] J.H. Chen, Gender difference and job replacement for mutual fund, *Quality and Quantity*, **44**, (2010), 661-671.
- [2] C.R. Wann and B.J. Lobo, Gender-based trading: evidence from a classroom experiment, *Journal of Economics and Finance Education*, **9**(2), (2010), 54-61.
- [3] M. Niederle and L. Vesterlund, Do women shy away from competition? Do men compete too much?, *Quarterly Journal of Economics*, **122**(3), (2006), 1067-1101.
- [4] R. Bliss and M. Potter, Mutual fund managers: does gender matter?, *Journal of Business and Economic Studies*, **8**(1), (2002), 1-17.
- [5] J.H. Golec, The effects of mutual fund managers' characteristics on their portfolio performance, risk, and fees, *Financial Services Review*, **5**, (1996), 133-148.
- [6] J. Chevalier and G. Ellison, Are some mutual fund managers better than others? cross-sectional patterns in behavior and performance, *Journal of Finance*, **54**(3), (1999), 875-899.
- [7] W.F. Sharpe, Mutual fund performance, *Journal of Business*, **39**(1), (1966), 119-138.
- [8] J.L. Treynor, How to rate management of investment funds, *Harvard Business Review*, **43**(1), 63-75.
- [9] M.C. Jensen, The performance of mutual funds in the period 1945-1964, *Journal of Finance*, **23**(2), (1968), 389-416.
- [10] E.F. Fama and K.R. French, Common risk factors in the returns on stocks and bonds", *Journal of Financial Economics*, **33**(1), (1993), 3-56.
- [11] M.M. Carhart, On persistence in mutual fund performance, *Journal of Finance*, **52**(1), (1997), 57-82.
- [12] H.O. Fried, S.S. Schmidt and S. Yaisawarng, Incorporating the operating environment into a nonparametric measure of technical efficiency, *Journal of Productivity Analysis*, **12**(3), (1999), 249-267.

- [13] B.P.S. Murthi, Y.K. Choi and P. Desai, Efficiency of mutual funds and portfolio performance measurement: a non-parametric approach, *European Journal of Operational Research*, **98**(2), (1997), 408-418.
- [14] A. Charnes, W.W. Cooper and E. Rhodes, Measuring the efficiency of decision making units, *European Journal of Operational Research*, **2**(6), (1978), 429-444.
- [15] A. Basso and S.A. Funari, Data envelopment analysis approach to measure the mutual fund performance, *European Journal of Operational Research*, **135**(3), (2001), 477-492.
- [16] Y.K. Choi, Relative portfolio performance evaluation and incentive structure, *Journal of Business*, **79**(2), (2006), 903-922.
- [17] J.K. Sengupta and T. Zohar, Nonparametric analysis of portfolio efficiency, *Applied Economics Letters*, **8**(4), (2001), 249-252.
- [18] R.I. Anderson, C.M. Brockman, C. Giannikos and R.W.A. McLeod, Non-parametric examination of real estate mutual fund efficiency, *International Journal of Business and Economics*, **3**(3), (2004), 225-238.
- [19] M. Devaney and W.L. Weber, Efficiency, scale economies, and the risk/return performance of real estate investment trusts, *Journal of Real Estate Finance and Economics*, **31**(3), (2005), 301-317.
- [20] G.N. Gregoriou, K. Sedzro K and J. Zhu, Hedge fund performance appraisal using data envelopment analysis, *European Journal of Operational Research*, **164**(2), (2005), 555-571.
- [21] U.D. Kumar, A.B. Roy, H. Saranga and K. Singal, Analysis of hedge fund strategies using slack-based DEA models, *Journal of the Operational Research Society*, **61**(12), (2010), 1746-1760.
- [22] C.R. Chen, C.F. Lee, S. Rahman and A. Chan, A Cross-sectional analysis of mutual funds' market timing and security selection skill, *Journal of Business Finance and Accounting*, **19**(5), (1992), 659-675.
- [23] J. Annaert, J. van den Broeck and R.V. Vennet, Determinants of mutual fund underperformance: a Bayesian stochastic frontier approach, *European Journal of Operational Research*, **151**(3), (2003), 617-632.
- [24] J.L. Hu and T.P. Chang, Decomposition of mutual fund underperformance, *Applied Financial Economics Letters*, **4**(5), (2008), 363-367.
- [25] L. Prather, W.J. Bertin and T. Henker, Mutual fund characteristics, managerial attributes, and fund performance, *Review of Financial Economics*, **13**(4), (2004), 305-326.
- [26] D. Hendricks D, J. Patel and R. Zeckhauser, Hot hands in mutual funds: short-run persistence of relative performance 1974-1988, *Journal of Finance*, **48**(1), (1993), 93-130.
- [27] J.G. Kallberg, C.L. Liu and C. Trzcinka, The value added from investment managers: an examination of funds of REITs, *Journal of Financial and Quantitative Analysis*, **35**(3), (2000), 387-408.
- [28] R. Fortin, S. Michelson and J. Jordan-Wagner, Does mutual fund manager tenure matter?, *Journal of Financial Planning*, **12**(7), (1999), 72-79.

- [29] B.J. Costa, K. Jakob, G.E. Potter, Mutual fund performance and changing market trends 1990-2001: does manager experience matter?, *Journal of Investing*, **15**(2),(2006), 79-86.
- [30] L.N. Switzer and Y. Huang, How does human capital affect the performance of small and mid-cap mutual funds?, *Journal of Intellectual Capital*, **8**(4), (2007), 666-681.
- [31] A.A. Gottesman and M.R. Morey, Manager education and mutual fund performance, *Journal of Empirical Finance*, **13**(2), (2006), 145-182.
- [32] A. Khorana, Top management turnover: an empirical investigation of mutual fund manager, *Journal of Financial Economics*, **40**(3), (1996), 403-427.
- [33] M. Powell and D. Ansic, Gender differences in risk behavior in financial decision-making: an experimental analysis, *Journal of Economic Psychology*, **18**(6), (1997), 605-628.
- [34] Ammon JN and Bernasek A, Are women more risk averse? , *Economic Inquiry*, **36**, (2007), 620-630.
- [35] R. Barsky, M.S. Kimball, F.T. Juster and M.D. Shapiro, Preference parameters and behavioral heterogeneity: an experimental approach in the health and retirement, *Quarterly Journal of Economics*, **112**(2), (1997), 537-579.
- [36] B.M. Barber and T. Odean, Boys will be boys: gender, overconfidence, and common stock investment, *Quarterly Journal of Economics*, **116**(1), (2001), 261-292.
- [37] S.M. Atkinson, S.B. Baird and M.B. Frye, Do female mutual fund managers manage differently?, *Journal of Financial Research*, **26**(1), (2003), 1-18.
- [38] L. Simar and P.W. Wilson, Estimation and inference in two-stage, semi-parametric models of production processes, *Journal of Econometrics*, **136**(1), (2007), 31-64.
- [39] C.A.K. Lovell and J.T. Pastor, Units invariance and translation invariant DEA models, *Operations Research Letters*, **18**(3), (1995), 147-151.
- [40] R.D. Banker, A. Charnes and W.W. Cooper, Some models for estimating technical and scale inefficiencies in data envelopment analysis, *Management Science*, **30**(9), (1984), 1078-1092.
- [41] Taiwan Economic Journal. Website: <http://www.Finasia.biz>.
- [42] FundDJ. Website: <http://www.moneydj.com/funddj/>