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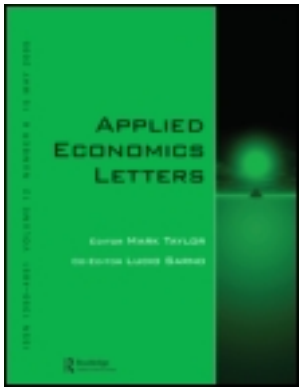

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Detecting mutual fund timing ability using the threshold model

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Detecting mutual fund timing ability using the threshold model

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This paper proposes a new method based on threshold regression to test mutual fund market-timing abilities. The traditional Henriksson and Merton model is shown to represent only a special case within the proposed model. The potential bias of using the traditional model is demonstrated and it is argued that the proposed model provides more accurate inferences on the market-timing effects of mutual funds. The empirical results for a set of randomly-selected US mutual funds indicate the superior performance of the proposed method in detecting the market-timing ability.

I. Introduction

Investment performance and the market timing of mutual funds continue to receive considerable attention by both academics and market practitioners alike, with a variety of evaluation techniques having been proposed and implemented over the years. Treynor (1965), Sharpe (1966) and Jensen (1968), for example, measured the excess returns for systematic risk,[1] while more recently, Bollen and Busse (2001) and Chance and Helmer (2001) have stressed the importance of daily tests for performance measurement.

This paper proposes a new method of testing mutual fund performance and market timing through the application of threshold regression techniques. The idea is that fund managers may adopt different trading strategies when they perceive different market conditions. As fund managers may not uniformly use the sign of the market return to capture the direction of market movement, it is natural to conjecture that a fund manager's trading behaviour changes when the market return is above or below a certain threshold level, which varies across managers of different funds.

Threshold models have been widely applied in the econometric analysis; the threshold autoregressive (TAR) model, for example, remains popular in the examination of nonlinear time-series data. Abdulai (2002) provides an application of the TAR model. Hansen (2000) presented a statistical theory for threshold estimation, in a regression context, proposing least squares estimation of the regression parameters and concluding with the asymptotic distribution theory for the regression estimates.

This paper aims to contribute to this field through the introduction of the threshold model into the testing of mutual fund market-timing effects. The traditional Henriksson and Merton (1981) model

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[1] Treynor and Mazuy (1966), Henriksson and Merton (1981) and Chang and Lewellen (1984) noted that investment managers have superior information and forecasting skills.

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is shown to represent only a special case within our model, and we demonstrate the potential bias of using the traditional model, arguing that it tends to underestimate the market-timing effect. Indeed, we find that the use of the traditional market timing test may provide misleading results in some circumstances; thus, our proposed threshold model provides more accurate inferences on the market-timing effects of mutual funds.

II. Threshold Model and Market Timing

Models for mutual fund performance and market-timing effects

We begin by using the threshold regression model developed by Hansen (1996) to propose a model for testing mutual fund performance and market-timing effects. The threshold regression model takes the form:

$$\begin{aligned} R_i - R_f &= \alpha_i^1 + \beta_i^1\left(R_m - R_f\right) + e_i \quad R_m - R_f \le q_i \\ R_i - R_f &= \alpha_i^2 + \beta_i^2\left(R_m - R_f\right) + e_i \quad R_m - R_f > q_i \end{aligned} \tag{1}$$

where R_i is the rate of return on the ith mutual fund; R_m is the rate of return on the market portfolio; R_f is the riskless rate; q_i is the threshold parameter; $\alpha_i^1(\alpha_i^2)$ is the abnormal return of the ith mutual fund when the excess return rate on the market portfolio is smaller (larger) than the threshold variable; and $\beta_i^1(\beta_i^2)$ is the systematic risk of the ith mutual fund when the excess return on the market portfolio is smaller (larger) than the threshold variable. If there is any significant increase in systematic risk, $(\beta_i^2 > \beta_i^1)$, fund managers will have market-timing ability.

The Henriksson and Merton (1981) model can be written as follows:

$$\begin{aligned} R_i - R_f = \alpha_i &+ \beta_{i1}\left(R_m - R_f\right) \\ &- \beta_{i2} \cdot d_m(0) \cdot \left(R_m - R_f\right) + e_i \end{aligned} \tag{2}$$

where $d_m(0) = I\{R_m - R_f < 0\}$ is the dummy variable with $I\{\cdot\}$ as the indicator function; α_i is the abnormal return of the ith mutual fund; β_{i1} and (β_{i2}) are beta regression coefficients; and the fund manager's market-timing ability is expressed as β_{i2}. It is clear that the traditional Henriksson and Merton (1981) model is a special case of the threshold regression model in Equation 1 where q to the value of 0.

The above threshold regression model (1) can be rewritten as follows:

$$r_i = \theta_1' \cdot r_m^* + \lambda' \cdot r_m^*(q) + e_i$$

where $r_m^* = [1^* r_m]$, $r_m^*(q) = [1^*(r_m d_m(q))]$, r_m is the $n \times 1$ vector of excess return rate on the market portfolio; and 1* is a column vector of ones. r_m^* and r_m^* are both $n \times 2$ matrices; n represents the number of observations on the ith mutual fund; $d_m(q) = I\{r_m > q\}$ is the dummy variable with $I\{\cdot\}$ as the indicator function; r_i is the $n \times 1$ vector of excess return rate on the ith mutual fund; θ_1 is the vector of coefficients of the model when the excess return on the market portfolio is smaller than the threshold variable; θ_2 is the vector of coefficients of the model when the excess return on the market portfolio is greater than the threshold variable; $\lambda = \theta_2 - \theta_1$ denotes the 'threshold effect'; and e_i is the $n \times 1$ vector of error. If the results of the test on λ are significantly different from zero, this will indicate that the manager possesses market-timing ability.

The regression parameters are estimated by the least squares method, with the sum of the squared errors function being shown as:

$$\begin{aligned} &S_n(\theta_1, \lambda, q) \\ &\quad = \left(r_i - \theta_1' \cdot r_m^* - \lambda' \cdot r_m^*(q)\right)' \cdot \left(r_i - \theta_1' \cdot r_m^* - \lambda' \cdot r_m^*(q)\right) \end{aligned}$$

Conditional on q yielding the OLS estimators $\hat{\theta}(q)$ and $\hat{\lambda}(q)$, by regression of r_i on $(r_m^*, r_m^*(q))$, the concentrated sum of the squared errors function is

$$\begin{aligned} S_n(q) &= S_n\left(\hat{\theta}_1(q), \hat{\lambda}(q), q\right) \\ &= r_i' \cdot r_i - r_i' \cdot r_m^{q*}\left(r_m^{q*'} r_m^{q*}\right)^{-1} r_m^{q*'} r_i \end{aligned}$$

where $r_m^{\dot{q}}$ is the excess return on the market portfolio under the threshold condition. For the minimization of the sum of the squared errors, q is assumed to be restricted to a bounded set (empirically, it usually uses the 15% quartile of the sample to the 85% quartile of the sample); the least-squares estimate $\hat{q}$ of the threshold parameter q is the value which minimizes $S_n(q)$. The consistency threshold estimate $\hat{q}$ is defined as:

$$\hat{q} = \arg\min S_n(q)$$

Note that the LS estimator is also the MLE when e_i is *i.i.d.* $N(0, \sigma^2)$. Hansen (2000) provided the asymptotic distribution of the consistent threshold estimate $\hat{q}$, and suggested the use of the likelihood ratio statistic to test the hypothesis H_0: $q = q_0$ under the condition of e_i being *i.i.d.* $N(0, \sigma^2)$. The likelihood ratio statistic under homoscedasticity is different from that under heteroscedasticity. The test proposed by White (1980) can be employed to examine the homoscedastic disturbances.

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Under the assumption of homoscedasticity, the likelihood ratio statistic for $q = q_0$ is defined as

$$LR(q_0) = n \cdot \frac{S_n(q_0) - S_n(\hat{q})}{S_n(\hat{q})} \tag{3}$$

The likelihood ratio test of H_0 is rejected for large values of $LR_n(q_0)$. If heteroscedasticity exists, the likelihood ratio statistic under $q = q_0$ is defined as:

$$LR^*(q_0) = \frac{LR(q_0)}{\hat{\eta}^2} = n \cdot \frac{S_n(q_0) - S_n(\hat{q})}{S_n(\hat{q}) \cdot \hat{\eta}^2} \tag{4}$$

where $\hat{\eta}^2$ is an estimator of

$$\eta^2 = \frac{c' E\left(r_m r_m' e_i^2 | q = q_0\right) c}{\sigma^2 \cdot c' E(r_m r_m' | q = q_0) c}$$

As demonstrated in both Henriksson and Merton (1981) and Chang and Lewellen (1984), we can use the excess return on the market portfolio to determine whether or not a bull market exists. Our aim is to test whether the market managers are able to adjust their investment principles according to the market index; that is, to test the hypothesis H_0: $q = 0$.

Testing for threshold effects

Using the changes in the regression coefficients of the threshold estimate allows us to evaluate the mutual fund manager's stock-selection and market-timing abilities. We construct the hypothesis H_0: $\lambda = 0$ to test for the threshold effect.

If the fund manager does not exhibit market timing behaviour, the conditional sum of the squared errors $S_n(q_0)$ of (3) and (4) will be equal to the sum of the squared errors ($e_i' e_i$) in the traditional one-regime CAPM (i.e., $r_i = \theta' \cdot r_m + e_i$).

In the presence of homoscedasticity, the likelihood ratio statistic is defined as:

$$LR = n \cdot \frac{e_i' e_i - S_n(\hat{q})}{S_n(\hat{q})} \tag{5}$$

Under H_0 the threshold q remains unidentified; therefore, the classical tests have non-standard distribution. Hansen (1996) suggested the adoption of a bootstrap to simulate the asymptotic distribution of the likelihood ratio test, showing that a bootstrap procedure attains the first-order asymptotic distribution; thus, the p-values constructed for the bootstrap are asymptotically valid. We use bootstrap replication to generate a bootstrap sample of size 1000 so that the residual features are the same as those of an individual mutual fund. The small sample distribution and the p-value of the likelihood ratio test estimator are then obtained.

Test for the source of the threshold effect

In order to test whether the threshold effect stems from manager's stock-selection ability or market-timing ability, we use the threshold estimate as the dummy variable, thereby dividing the mutual fund samples into two sample sets. We then construct a test which can determine whether the threshold effect comes from manager's stock-selection ability or market-timing ability. The model constructed is similar to the Fabozzi and Francis (1979) model, as follows:

$$r_i = \alpha_i + \lambda_1 d_m^*(\hat{q}) + \beta_i r_m + \lambda_2 d_m^*(\hat{q}) r_m + e_i \tag{6}$$

where $d_m^*(\hat{q}) = I\{r_m > \hat{q}\}$ is the dummy variable with $I\{\cdot\}$ as the indicator function; $\hat{q}$ is the threshold estimator; α_i is the excess return rate on the ith mutual fund without threshold effect; β_i is the systematic risk of the ith mutual fund without threshold effect, λ_1 is the abnormal return disparity under ($r_m > \hat{q}$); λ_2 is the systematic risk disparity of the ith mutual fund under ($r_m > \hat{q}$); and e_i is a regression error. The aim of constructing the hypothesis test is to determine whether the threshold effect stems from manager's stock-selection ability or market-timing ability; this is undertaken by testing to see whether the corresponding differential coefficient is statistically different from zero. A positive value of λ_1 represents that the fund manager presents sufficient stock-selection ability in anticipation of a bull market, while a positive λ_2 indicates that the fund manager has market-timing ability.

III. Data and Empirical Results

Bollen and Busse (2001) demonstrated that daily tests are more forceful than monthly tests, with mutual funds more often displaying significant timing ability from such daily tests; hence, our analysis of the market-timing effect is based upon the daily returns of 30 randomly selected mutual funds. The sample is taken from the aggressive growth mutual fund of the Center for Research in Security Prices (CRSP) mutual fund database, with the sample period running from 1 January 2000 to 31 January 2003. We employ the net asset value and dividends to form a daily return series for each fund. We use the CRSP value-weighted index, including NYSE, AMEX and NASDAQ stocks, as an overall market benchmark. Three-month Treasury Bills rates, drawn from the Federal Reserve Board, are used as the risk-free rates.

Table 1. Estimation results of mutual fund market-timing effect using the threshold model.

Fund name	Threshold variables	α_i^{1}[b]	β_i^{1}[c]	α_i^{2}[b]	β_i^{2}[c]	p-value[d]
Bear Stearns Small Cap Value Portfolio/C	−0.0087	0.005	1.174	0.000	0.825	0.065*
		(3.013)	(12.363)	(0.110)	(20.553)	
Dreyfus Founders Funds: Discovery Fund/T	0.0057	−0.001	1.003	0.003	0.856	0.080*
		(−2.322)	(25.305)	(2.588)	(13.733)	
Oppenheimer Discovery Fund/A	−0.0025	−0.002	0.874	0.001	0.844	0.005**
		(−2.603)	(16.867)	(2.691)	(22.401)	
INVESCO Dynamics Fund/Instl	−0.0061	−0.007	1.091	0.000	1.391	0.004**
		(−4.423)	(11.966)	(0.396)	(29.474)	
NI Numeric Investors Growth Fund	0.0072	0.000	1.070	0.004	0.890	0.097*
		(−0.699)	(30.497)	(3.054)	(14.336)	
Quaker Aggressive Growth Fund	0.0055	−0.001	0.227	0.004	−0.021	0.000**
		(−2.337)	(8.951)	(5.569)	(−0.536)	
Smith Barney Small Cap Core Fund/B	−0.0086	−0.008	0.839	−0.001	1.240	0.006**
		(−4.845)	(8.050)	(−3.370)	(33.872)	
Royce Fund: Opportunity/ Instl Serv	−0.0025	0.000	0.836	0.002	0.652	0.012**
		(0.458)	(15.681)	(3.798)	(16.728)	
TD Waterhouse Extended Market Index Fund	0.0075	0.000	1.003	0.003	0.821	0.058*
		(−0.056)	(39.384)	(3.027)	(17.373)	
Aetna Index Plus Small Cap Fund/I	0.0074	0.000	0.864	0.004	0.703	0.057*
		(0.05)	(30.017)	(3.588)	(13.249)	
AIM Small Cap Opportunities	−0.0029	−0.003	0.603	0.000	0.752	0.038**
		(−3.590)	(10.035)	(0.782)	(17.947)	
Analysts Aggressive Stock Fund	−0.0061	−0.004	0.997	0.001	1.162	0.052*
		(−3.099)	(12.970)	(1.412)	(29.191)	
J Hancock Small Cap Growth Fund/I	−0.0025	−0.002	1.009	0.001	1.006	0.076*
		(−2.563)	(17.960)	(1.772)	(24.495)	
Undiscovered Managers Small Cap Growth/Instl	0.0079	−0.001	1.377	0.009	0.955	0.003**
		(−0.712)	(22.378)	(3.933)	(8.298)	
Merrill Lynch Master Small Cap Vl Tr Fund/B	−0.0025	−0.001	0.868	0.002	0.828	0.046**
		(−1.237)	(18.434)	(3.442)	(24.024)	
Lord Abbett Developing Growth Fund/A	−0.0037	−0.002	0.955	0.001	0.910	0.055*
		(−1.836)	(16.560)	(2.151)	(24.286)	
State Street Research: Emerging Growth Fund/B1	0.0072	0.000	1.061	0.006	0.782	0.003**
		(−0.502)	(26.615)	(4.300)	(11.090)	

Notes: [a]This table presents the estimation results for the model: $R_i - R_f = \alpha_i^1 + \beta_i^1(R_m - R_f) + e_i \quad R_m - R_f \le q$; $R_i - R_f = \alpha_i^2 + \beta_i^2(R_m - R_f) + e_i \quad R_m - R_f > q$; where q is the threshold parameter; R_i is the return rate of the ith mutual fund; and R_m is the return rate on the market portfolio.

[b]$\alpha_i^1(\alpha_i^2)$ is an abnormal return of the ith mutual fund when the excess return rate on the market portfolio is smaller (larger) than the threshold estimate.

[c]$\beta_i^1(\beta_i^2)$ is the systematic risk of the ith mutual fund when the excess return rate on the market portfolio is smaller (larger) than the threshold estimate.

[d]The null hypothesis of the test is $\theta_2 - \theta_1 = 0$, where $\theta_1 = (\alpha_i^1 \beta_i^1)'$ and $\theta_2 = (\alpha_i^2 \beta_i^2)'$. Figures in parentheses are t-values.

[e]* Indicates significance at the 10% level. ** Indicates significance at the 5% level.

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Our results show that half of the mutual funds beat the market.[2]

The results in Table 1 demonstrate that 17 of the funds have threshold effects and that the abnormal returns of 16 of the 17 funds are both significant and positive ($\alpha_i^2 > \alpha_i^1$), which indicates that the managers have stock-selection abilities. Only four of the 17 fund managers have market-timing ability because there is a significant increase in their systematic risks ($\beta_i^2 > \beta_i^1$); four of the 17 funds possess both stock-selection and market-timing abilities. Furthermore, superior fund managers will increase the systematic risk of a portfolio in anticipation of a bull market, so as to raise the risk premium and reduce the systematic risk of the portfolio, thus reducing losses when a bear market is forecasted.

The traditional Henriksson and Merton Model is the threshold regression model, with the restriction that $q = 0$. The results of Table 2 reveal that 11 of the 17 funds show a rejection of the null hypothesis

[2] The results are omitted to save space. However, they are available upon request.

Table 2. Results of tests for the threshold variable of market timing being equal to zero

Fund name	LR[a]	*p*-value[b]
Bear stearns small cap value portfolio/C	8.744	0.438
Dreyfus founders funds: discovery fund/T	8.413	0.073*
Oppenheimer discovery fund/A	9.100	0.042
INVESCO dynamics fund/instl	8.570	0.009**
NI numeric investors growth fund	8.717	0.086*
Quaker aggressive growth fund	8.774	0.007**
Smith Barney small cap core fund/B	8.790	0.023**
Royce fund: opportunity/instl serv	8.700	0.530
TD waterhouse extended market index fund	8.872	0.288
Aetna index plus small cap fund/I	8.552	0.026**
AIM small cap opportunities	8.001	0.035**
Analysts aggressive stock fund	8.560	0.022**
J Hancock small cap growth fund/I	8.602	0.332
Undiscovered managers small cap growth/instl	8.547	0.003**
Merrill Lynch master Sm Cp Vl Tr fund/B	8.851	0.167
Lord Abbett developing growth fund/A	8.658	0.089*
State street research: emerging growth fund/B1	8.609	0.010**

Notes: [a]The null hypothesis of LR is $q = 0$.
[b]* Indicates significance at the 10% level. ** Indicates significance at the 5% level.

Table 3. Mutual fund market timing and performance test, threshold model versus Henriksson and Merton model

	Threshold regression model[a]				Henriksson and merton model[b]		
Fund name	α	β	$\lambda_1(\hat{q})$	$\lambda_2(\hat{q})$	α	β_1	β_2
INVESCO dynamics fund/instl	−0.007	1.091	0.007	0.300	−0.001	1.438	0.027
	(−4.42)	(11.96)	(4.28)**	(2.92)**	(−1.19)	(28.05)	(0.30)
Smith barney small cap core fund/B	−0.008	0.839	0.007	0.401	−0.001	1.259	0.041
	(−4.845)	(8.050)	(4.075)**	(3.631)**	(−3.424)	(27.046)	(0.502)
AIM small cap opportunities	−0.003	0.603	0.004	0.150	−0.001	0.806	0.056
	(−3.59)	(10.04)	(3.48)**	(2.04)**	(−1.25)	(19.75)	(0.80)
Analysts aggressive stock fund	−0.004	0.997	0.005	0.165	−0.001	1.202	0.001
	(−3.10)	(12.97)	(3.40)**	(1.90)*	(−0.08)	(27.98)	(0.01)

Notes: [a]This table presents threshold regression results for the model: $r_i = \alpha_i + \lambda_1 d_m^*(\hat{q}) + \beta_i r_m + \lambda_2 d_m^*(\hat{q}) r_m + e_i$, where $d_m^*(\hat{q}) = I\{r_m > \hat{q}\}$ is the dummy variable with $I\{\cdot\}$ as the indicator function; $\hat{q}$ is the threshold estimator.
[b]Figures in parentheses are *t*-values.
[c]* Indicates significance at the 10% level. ** Indicates significance at the 5% level.

that $q = 0$; therefore, the traditional Henriksson and Merton (1981) model is rejected. Hence, we demonstrate that there is potential bias in the use of the traditional model.[3]

The model employed in this study essentially explores the assumption of the existence of a threshold effect. This assumption is important because it affects our evaluation of the investment performance of mutual fund managers. For example, as demonstrated in Table 3, under the traditional model of Henriksson and Merton (1981), four of the funds indicate that the fund managers do not possess any market-timing or stock-selection ability; however, the results from our threshold model show that the fund managers not only achieved more abnormal returns, but also increased the systematic risk so as to earn higher market risk premiums once the market excess return was larger than the threshold estimate.

[3] The regression results of the threshold effect from Equation 6 are omitted for saving space. Sixteen of the mutual funds exhibited a positive and significant value for $\lambda_1(\hat{q})$, indicating that the fund manager has stock-selection ability based upon the threshold effect. Four of the mutual funds also exhibited a positive and significant value for $\lambda_2(\hat{q})$, indicating that the fund manager has market-timing ability based upon the threshold effect.

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IV. Conclusions

This study has proposed the use of the threshold regression model to evaluate the market-timing abilities of mutual fund managers. The empirical results for a set of randomly selected US mutual funds indicate that the threshold values of market timing are different from 0 for more than 50% of the mutual funds. Our results indicate potential bias in the use of the traditional Henriksson and Merton (1981) model with regard to its evaluation of the ability of fund managers to select stocks, and we find that the traditional model also tends to underestimate the market-timing effect under the use of the capital asset pricing model with threshold effects.

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