An investigation on impacts of structural changes in stocks' past returns on financial analysts' earnings forecasting rationality

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Zhixin Kang
Economics and Decision Sciences,
University of North Carolina at Pembroke, Pembroke, North Carolina, USA

Abstract

Purpose – The purpose of this paper is to test whether financial analysts' rationality in making stocks' earnings forecasts is homogenous or not across different information regimes in stocks' past returns.

Design/methodology/approach – By treating stocks' past returns as the information variable in this study, the authors employ a threshold regression model to capture and test threshold effects of stocks' past returns on financial analysts' rationality in making earnings forecasts in different information regimes.

Findings – The results show that three significant structural breaks and four respective information regimes are identified in stocks' past returns in the threshold regression model. Across the four different information regimes, financial analysts react to stocks' past returns quite differently when making one-quarter ahead earnings forecasts. Furthermore, the authors find that financial analysts are only rational in a certain information regime of stocks' past returns depending on a certain return-window such as one-quarter, two-quarter or four-quarter time period.

Originality/value – This study is different from those in the existing literature by arguing that there could exist heterogeneity in financial analysts' rationality in making earnings forecasts when using stocks' past returns information. The finding that financial analysts react to stocks' past returns differently in the different information regimes of past returns adds value to the research on financial analysts' rationality.

Keywords Structural change, Earnings forecasting, Financial analysts' rationality, Information regime

Paper type Research paper

1. Introduction

Financial analysts routinely make forecasts on earnings per share (EPS) for the stocks they follow. Both institutional and individual investors incorporate earnings forecasts information in their stock investment decision making and transactions. As such, studying the mechanism of financial analysts' earnings forecasts is very important to stock investors. There has been a rich literature exploring financial analysts' rationality in making EPS forecasts. Financial analysts' rationality is referred to as a decision-making process in which a forecasted EPS is logically based on the information available at the forecasting time (Keane and Runkle, 1990). When making EPS forecasts, financial analysts use different sources of information. This study focuses on investigating financial analysts' rationality in using stocks' past return information to make EPS forecasts. Abarbanell (1991) shows that financial analysts do not fully use the information reflected in stocks' past returns. Lys and Sohn (1990) also report that analysts' earnings forecasts do not incorporate the full information contained in stocks' past returns prior to forecast-release dates. Basu and Markov (2004), using a linear loss regression methodology, show that financial analysts' earnings forecasts are not statistically efficient

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when stocks' past buy-and-hold returns serve as a predictor variable in the linear regression model. Muslu and Xue (2013) report that financial analysts' momentum recommendations reflect different sides of stocks' past returns. Jung *et al.* (2015) find that analysts incorporate the information of stocks' past returns when making revisions on earnings forecasts. Based on these findings, it suggests that analysts may not be fully rational when making earnings forecasts in using the information about stocks' past returns. To this end, a further question to ask is whether analysts' rationality in making earnings forecasts is homogenous or not if there exist significant structural changes in stocks' past returns. Specifically, would a financial analyst have the same extent of rationality in making earnings forecasts in the presence of significant regime shifts in a stock's past returns? Answering this question could help both practitioners and researchers better understand the behavior of financial analysts in making earnings forecasts. The purpose of this study is to add insights into this research. We use stocks' past returns as the information variable in this study. Using an econometric approach, we test whether financial analysts' rationality in making stocks' earnings forecasts is homogenous or not across different information regimes in stocks' past returns.

The remainder of the paper is organized as follows. The next section reviews the existing literature about this research topic. Section 3 illustrates the research methodology. Section 4 describes the data and the statistical summary. Section 5 presents and analyzes the empirical results. Conclusions are presented in Section 6. Section 7 summarizes the implications and limitations of this study, as well as the future research plan.

2. Literature review

Researchers have made significant findings on the relationship between financial analysts' earnings forecasts and stocks' past returns. Lys and Sohn (1990), using a sample of 58 companies during 1980 to 1986, show that analysts only incorporate about 66 percent of the information contained in stocks' prior returns when making earnings forecasts. Abarbanell (1991) finds that even though there is a positive association between earnings revisions and past returns, the information of stocks' past returns is not fully reflected in earnings revisions made by financial analysts who follow the stocks' price changes. Cooper *et al.* (2001) report that financial analysts do use the information of recent excess returns to update their earnings forecasts. Clement *et al.* (2011) reveal that financial analysts, when forecasting future earnings, respond to past returns differently depending on how informative the past returns are about future earnings' changes. More recently, Dong *et al.* (2016) add to the existing literature that financial analysts indeed use the information about stocks' past returns in their earnings revisions. However, they find that 50 percent of these revisions are inconsistent with the signs of the past returns. Basu and Markov (2004) point out that even though financial analysts do use the information of stocks' past buy-and-hold returns when making earnings forecasts, these forecasts are economically efficient but not statistically efficient. It follows from the existing literature that stocks' past returns indeed influence analysts' earnings forecasts or revisions, but the information of stocks' past returns is not fully reflected in earnings forecasts.

From the methodological perspective, several approaches are developed to study the relationship between financial analysts' earnings forecasts and stocks' past returns. Abarbanell (1991) employs a non-parametric methodology to test the hypothesized positive association between financial analysts' earnings revisions and the accumulated past returns up to ten days prior to a public forecast release date of earnings. The test statistic in this method is computed as the difference between the frequency of upward earnings revisions (errors) conditional on increased past returns and the frequency of upward earnings revisions (errors) conditional on decreased past returns. Other researchers employed a parametric approach to test financial analysts' rationality using stocks' past returns as a predictor variable. Lys and Sohn (1990) use a linear regression model to test the relationship between the revisions of earnings forecasts (dependent variable) and returns (independent variable) of a whole stock market as well as the returns of 58 individual stocks. They test financial analysts' rationality by analyzing the coefficients in the linear regression model. Ali *et al.* (1992) also use a linear regression model to test whether financial analysts' earnings forecasts reflect the information contained in stocks' past returns. As they study the serial correlation in financial analysts' forecast errors, they control for stocks' past returns in the linear regression model. They test the statistical significance of the coefficient associated with the variable of past returns in the model and explore whether stocks' past returns have predicting power for financial analysts' earnings forecasts. In the studies of Lys and Sohn (1990) and Ali *et al.* (1992), the coefficients in the linear regression models are estimated based on the ordinary least square method in the sense that the loss function is assumed to be quadratic. Basu and Markov (2004) argue that a quadratic loss function may not be able to well explain the relationship between earnings forecasts and stocks' past returns. As such, they propose to use a linear loss function such as absolute forecast errors instead of a quadratic loss function in estimating the coefficients in a linear regression model. They regress actual earnings on forecasted earnings with stocks' past returns being included as an information variable in the linear regression model. Under a linear loss function framework, they test the statistical significance of the coefficient of the past returns variable. They find that financial analysts' earnings forecasts are not statistically efficient when stocks' past buy-and-hold returns serve as an information variable if a linear loss function is used in the model's estimation. Easterwood and Nutt (1999) study the rationality of financial analysts in making earnings forecasts and conclude that analysts are systematically optimistic – they underreact to negative information and overreact to positive information. Clatworthy *et al.* (2011) study the financial analysts' asymmetric loss function. They explain why financial analysts' positive and negative EPS forecast errors are not symmetrically penalized or rewarded. All these findings conclude that financial analysts are not fully rational in making earnings forecasts. Researchers also study the distributional characteristics of EPS forecasts. Truong *et al.* (2018) investigates the information contained in EPS forecasts' tail area and report that significant information in the tail area is related to equity market movement, including that in stock returns. Furthermore, they show that trading a long or short position constructed on the basis of EPS tail information can help generate higher profit in a hedge fund portfolio. It is worth noting that the aforementioned parametric approach in a linear regression model with either a quadratic or a linear loss function, does not consider the impact of (possible) structural changes in stocks' past returns on coefficient estimates and their respective statistical inferences. In other words, this approach assumes that stocks' past returns would have a homogenous impact on financial analysts' earnings forecasts. From an economic point of view, a stock's past returns could be extremely high or low enough so as to trigger a financial analyst's different reactions in making or revising his/her earnings forecasts for the stock. From an econometric perspective, this is a statistical testing of financial analysts' sensitivity to the structural changes in stock's past returns. Hansen (1999) proposes a threshold regression model to estimate the coefficients and make statistical inferences for these coefficients in different information regimes separated by the threshold (s). This model allows a simultaneous estimation of threshold(s) and coefficients based on a least square loss function, and the threshold variable in this model can either be endogenous or exogenous. Our study follows this methodology.

3. Research methodology

According to Keane and Runkle (1990), financial analysts' rationality in forecasting earnings can be tested using a linear regression model:

$$AE_{it} = \beta_{i,0} + \beta_1 FE_{i,t-k}^{t} + \gamma X_{i,t-k} + \varepsilon_{it}, \tag{1}$$

where AE_{it} is the actual earnings of stock i at time t; $FE_{i,t-k}^{t}$ the time-t earnings forecast made at time $t{-}k$ for stock i; $X_{i,t-k}$ the information variable at time $t{-}k$ for stock i; ε_{it} the error term, which is assumed to be identically distributed and independent of $FE^{t}_{i,t-k}$ and $X_{i,t-k}$. $\beta_{i,0}$ is the constant term specific to stock i, and β_1 is the slope coefficient associated with earnings forecast variable in the regression model. To test whether financial analysts are rational or not in making earnings forecasts, it is testing statistically the following hypothesis: $\beta_1 = 1$. The rationale behind this hypothesis is that if financial analysts are efficient in making earnings forecasts, then the actual earnings AE_{it} and the forecasted earnings $FE^{t}_{i,t-k}$ should be statistically close to each other. Testing rationality of financial analysts therefore is equivalent to testing whether $\beta_1 = 1$ in the model (1).

In model (1), however, it treats the effect of the information variable on β_1 as homogenous regardless of whether the information variable's structure is homogenous or not. In other words, a (possible) structural break(s) in the information variable is (are) not considered in model (1). In this study, stocks' past returns variable is used as the information variable. Research has shown that there exist structural breaks in stocks' returns (Ang and Timmermann, 2012; Hamilton and Susmel, 1994; Kim and Kon, 1999; Schaller and Van Norden, 1997).

Based on the findings in the aforementioned literature, we postulate that financial analysts might react to stocks' past return information differently in making EPS forecasts if there exist structural changes in this information variable. To this end, we adopt a threshold regression model proposed by Hansen (1999) to study how financial analysts' earnings forecasts react to structural change (s) in stocks' past returns. Suppose the variable X has m structural breaks at the threshold values $\omega_1, \omega_2, \ldots, \omega_m$, respectively, then there will exist m+1 information regimes in this variable. In this study, quarterly data are used to test whether financial analysts' rationality in making earnings forecasts is homogenous or not in different information regimes of stocks' past returns. We consider one-quarter ahead earnings forecasts, which are made during quarter $t{-}1$ for quarter t's earnings $FE^{t}_{i,t-k}$ for stock i. Regarding the information variable, namely, stocks' past returns, we respectively consider one-quarter, two-quarter, and four-quarter buy-and-hold past returns up to the end of quarter $t{-}2$, right prior to quarter $t{-}1$, during which financial analysts make one-quarter ahead forecasts for quarter t's earnings. The model that reflects this methodology is as follow:

$$\begin{aligned} AE_{it} = {} & \beta_{i,0} + \beta_1 FE^{t}_{i,t-1} I\left(X_{i,t-1} \leqslant \omega_1\right) + \beta_2 FE^{t}_{i,t-1} I\left(\omega_1 < X_{i,t-1} \leqslant \omega_2\right) \\ & + \cdots + \beta_m FE^{t}_{i,t-1} I\left(\omega_{m-1} < X_{i,t-1} \leqslant \omega_m\right) \\ & + \beta_{m+1} FE^{t}_{i,t-1} I\left(X_{i,t-1} > \omega_m\right) + \gamma X_{i,t-1} + \varepsilon_{it}, \end{aligned} \tag{2}$$

where $I(\cdot)$ is the indicator function. In model (2), $X_{i,t-1}$ is the threshold variable, which also serves as the information variable in the threshold regression model. $\beta_1, \beta_2, \ldots, \beta_{m+1}$ are the slope coefficients in the m+1 information regimes. To estimate model (2), Hansen (1999) propose to remove individual stock i's effect, $\beta_{i,0}$. As a result, the model (2) is transformed to the following form:

$$\begin{aligned} \overline{AE}_{it} = {} & \beta_1 \overline{FE}^{t}_{i,t-1} I\left(X_{i,t-1} \leqslant \omega_1\right) + \beta_2 \overline{FE}^{t}_{i,t-1} I\left(\omega_1 < X_{i,t-1} \leqslant \omega_2\right) \\ & + \cdots + \beta_m \overline{FE}^{t}_{i,t-1} I\left(\omega_{m-1} < X_{i,t-1} \leqslant \omega_m\right) \\ & + \beta_{m+1} \overline{FE}^{t}_{i,t-1} I\left(X_{i,t-1} > \omega_m\right) + \gamma \overline{X}_{i,t-1} + \bar{\varepsilon}_{it}, \end{aligned} \tag{3}$$

In model (3), testing whether financial analysts respond to the information homogenously in different information regimes when making earnings forecasts is to statistically test whether $\beta_1 = \beta_2 = \cdots = \beta_{m+1}$. Hansen (1999) proposes a method to simultaneously estimate all the parameters in model (3), including the threshold values $\omega_1, \omega_2, \ldots, \omega_m$. We follow this method to estimate the slope coefficients and test the threshold effects of the information variable, $X_{i,t-1}$.

4. Data

We use quarterly panel data in this study. The actual and forecasted quarterly EPS data are obtained from Institutional Brokers' Estimate System (I/B/E/S). The quarterly stock prices data are gathered by the Center for Research in Security Prices (CRSP). The quarterly stock prices are used to calculate the quarterly returns. I/B/E/S provides both historical EPS estimates and actuals with two different versions, one of which contains the summary of historical EPS estimates and actuals, and the other includes the detailed EPS estimates and actuals. The former, which is called summary statistics, summarizes at a consensus level the EPS estimates made by all the financial analysts who follow the same stock, and the latter, which is called Detail History, records each individual analyst's EPS estimates on a daily timeline. The I/B/E/S data compiled for EPS estimates have different frequencies in terms of forecasted fiscal periods, such as one semi-annual, two semi-annuals, one year, two years, one quarter or two quarters ahead, etc. We use one-quarter ahead EPS estimates/forecasts extracted from the I/B/E/S Summary Statistics data. The data includes both mean and median consensus estimates for EPS. Research has shown that mean consensus EPS estimates are inefficient (Kim *et al.*, 2001) as EPS summary information and median consensus EPS estimates are the optimal EPS estimates (Gu and Wu, 2003). Following the literature, we use median EPS estimates instead of mean EPS estimates in this study. For each quarter's EPS estimates, both mean and median estimates are collected in each monthly statistical period in I/B/E/S. We extract the median estimates published in the latest statistical period and use them as the EPS estimates (forecasts) for each quarter. The data from I/B/E/S in this study span from the Q3 of 1984 to Q2 of 2012 with 112 quarters[1]. As such, the CRSP data align with this time window as well. The finally matched I/B/E/S and CRSP data include those firms without any missing observations in both earnings and stock prices in the specified time horizon. Totally 212 firms and 112 quarters are included in the data with 23,744 observations.

The buy-and-hold return at the end of quarter t for a firm is calculated using the following log-return formula: $r_t = \ln(P_t) - \ln(P_{t-j})$, where P_t is the adjusted closing price at the end of quarter t, and P_{t-j} is the adjusted closing price at the end of quarter $t-j$. When $j = 1$, the return is one-quarter return from quarter $t-1$ to t; when $j = 2$, the return is two-quarter return from quarter $t-2$ to t; when $j = 4$, the return is four-quarter return from quarter $t-4$ to t. Following the literature (see, e.g. Basu and Markov, 2004), we scale the actual and forecasted earnings at time t by the closing price P_{t-j} at the end of quarter $t-j$.

Table I reports the summary statistics for the panel data from Q3 of 1984 to Q2 of 2012 when one-quarter, two-quarter and four-quarter buy-and-hold past returns are calculated. It shows that the means, medians, 25 percent percentiles and 75 percent percentiles of the EPS actuals and EPS forecasts are close to each other in all the three different buy-and-hold returns. The standard deviations of the EPS estimates are less than those of the EPS actuals in all the three different buy-and-hold returns. Both EPS actuals and estimates exhibit extremely high kurtosis, implying that the overall distributions of the EPS actuals and EPS estimates both have a sharper peak than that of a normal distribution. It is worth noting that the EPS actuals' distribution is significantly left skewed with a negative skewness while EPS estimates' distribution is extremely right skewed with a remarkably positive skewness. It indicates that there exist extremely low actual earnings for some firms during Q3 of 1984 and Q2 of 2012. During this time period, the US economy went through several downturns, including the Great Recession that occurred from December of 2007 to June of 2009. And some firms witnessed the worst performance in their stocks in decades during the Great Recession.

Statistics	Actual EPS	Forecasted EPS	Return
Panel 1: one-quarter buy-and-hold return			
Mean	0.0182	0.0190	0.0182
Minimum	−5.2078	−0.5284	−2.0727
25% percentile	0.0113	0.0115	−0.0584
Median	0.0165	0.0163	0.0282
75% percentile	0.0233	0.0226	0.1088
Maximum	1.4756	7.2756	1.2595
SD	0.0617	0.0572	0.1665
Kurtosis	4,267.4904	11,108.5830	9.7276
Skewness	−49.0998	89.4087	−1.1176
p-value for Jarque-Bera normality test	2.2 e-16	2.2 e-16	2.2 e-16
Panel 2: two-quarter buy-and-hold returns			
Mean	0.0179	0.0189	0.0358
Minimum	−5.2078	−0.5284	−2.8246
25% percentile	0.0113	0.0114	−0.0704
Median	0.0164	0.0163	0.0511
75% percentile	0.0231	0.0224	0.1607
Maximum	0.9398	7.2756	2.1826
SD	0.0609	0.0573	0.2363
Kurtosis	4,506.8559	11,186.2091	9.2281
Skewness	−52.0233	90.0176	−1.0803
p-value for Jarque-Bera normality test	2.2 e-16	2.2 e-16	2.2 e-16
Panel 3: four-quarter buy-and-hold returns			
Mean	0.0178	0.0184	0.0693
Minimum	−5.2078	−0.5284	−3.7670
25% percentile	0.0113	0.0114	−0.0808
Median	0.0163	0.0162	0.0901
75% percentile	0.0229	0.0223	0.2448
Maximum	0.9398	0.8456	2.4142
SD	0.0608	0.0311	0.3213
Kurtosis	4,631.4561	241.7041	7.9298
Skewness	−53.4354	11.1834	−1.0752
p-value for Jarque-Bera normality test	2.2 e-16	2.2 e-16	2.2 e-16

Table I. Summary statistics of the panel data (Q3 of 1984 – Q2 of 2012)

As a result, extremely negative actual earnings in these firms were observed. On the other hand, financial analysts are found to be optimistic in making earnings forecasts, as documented by Barber *et al.* (2007), O'Brien *et al.* (2005), Michaely and Womack (1999) and Lin and McNichols (1998), among others. The extremely high positive skewness in the distribution of EPS estimates in the data shows that there exist overestimated earnings made by financial analysts. Table I shows that both mean and median in the three different buy-and-hold past returns are positive. Furthermore, the median return is greater than the mean return, indicating that the distributions of all the three buy-and-hold returns are left skewed. This is in alignment with the negative skewness of the returns observed in Table I. The high kurtosis in the distribution of the returns indicates that there is remarkably high peak in its distribution. All the p-values from the Jarque-Bera normality test are close to zero, indicating that all these three variables do not follow a normal distribution. This is in line with the irregular skewnesses and kurtoses observed in these variables.

5. Results

In this study, we test analysts' rationality in different information regimes of stocks' past returns when they make one-quarter ahead forecasts for earnings, therefore we set $k = 1$ in the model (3). For the information variable, we use past one-quarter, two-quarter, and four-quarter buy-and-hold returns up to the end of quarter t–2, the quarter immediately before quarter t–1, during which an analyst makes quarter t's earnings forecast. Correspondingly, we test how past one-quarter, two-quarters and four-quarter return information at the end of quarter t–2, which is the most recent quarterly return information available prior to quarter t–1, affects analysts' rationality in making one-quarter ahead earnings forecasts, respectively. In estimating the threshold regression model, we do not pre-specify the number of the thresholds. The estimation process iteratively seeks optimal number of statistically significant thresholds and simultaneously estimates them together with other coefficients in the model.

5.1 Financial analysts' rationality test based on past one-quarter return information

Table II reports the test results for the threshold effects of past one-quarter returns. The critical values at 1, 5 and 10 percent significance level for testing the threshold effects are obtained using the bootstrapping technique proposed by Hansen (1999).

As is shown in Table II, all the test statistics for a single threshold, double and triple thresholds turn out to be much larger than the critical values at 1, 5 or 10 percent significance level, respectively. The respective p-values of these tests are almost zero. Therefore, three statistically significant thresholds are identified in the past one-quarter returns. Table III presents the estimated coefficients and thresholds in the model. The three estimated threshold values are $\hat{\omega}_1 = -0.3968$, $\hat{\omega}_2 = -0.2124$ and $\hat{\omega}_3 = 0.3744$, respectively. Therefore, the first structural break occurs when the past one-quarter

Table II. Tests for threshold effects of past one-quarter returns

	Test for single threshold	Test for double thresholds	Test for triple thresholds
Test statistic, F	3,201.75	541.27	717.17
p-value	0.00	0.00	0.00
1% critical value	52.55	62.11	130.14
5% critical value	30.01	20.16	12.37
10% critical value	17.68	12.98	8.01

Table III. Estimation results of the threshold model with three thresholds in past one-quarter returns

Coefficient	Estimate	SE	t-value
$\hat{\beta}_1$	1.2581	0.0428	29.3949
$\hat{\beta}_2$	−0.1915	0.0345	−5.5507
$\hat{\beta}_3$	1.0182	0.0152	66.9868
$\hat{\beta}_4$	0.0079	0.0073	1.0822
$\hat{\gamma}_1$	0.0123	0.0021	5.8571

Notes: This table reports the estimation results of the threshold model that identifies three thresholds in past one-quarter returns. The threshold regression model is in the form of:

$$\overline{AE}_{it} = \beta_1 \overline{FE}^t_{i,t-1} I(r_{i,t-1} \leqslant \omega_1) + \beta_2 \overline{FE}^t_{i,t-1} I(\omega_1 < r_{i,t-1} \leqslant \omega_2)$$

$$+ \beta_3 \overline{FE}^t_{i,t-1} I(\omega_2 < r_{i,t-1} \leqslant \omega_3) + \beta_4 \overline{FE}^t_{i,t-1} I(r_{i,t-1} > \omega_3) + \gamma_1 r_{i,t-1} + \bar{\varepsilon}_{it}$$

where $\overline{AE}_{it}$ and $\overline{FE}^t_{i,t-1}$ are demeaned actual and forecasted earnings, respectively; $r_{i,t-1}$ the past one-quarter return information of firm i during quarter t–1; ω_1, ω_2 and ω_3 the three thresholds in the model. The three estimated threshold values are:

$$\hat{\omega}_1 = -0.3968, \hat{\omega}_2 = -0.2124, \text{and } \hat{\omega}_3 = 0.3744$$

return equals −0.3968, or −39.68 percent; the second structural break occurs when the past one-quarter return equals −0.2124, or −21.24 percent; the third structural break occurs when the past one-quarter return equals 0.3744, or 37.44 percent. Correspondingly, four information regimes are identified. In the first information regime where the past one-quarter returns is less than or equals to −0.3968, the estimated coefficient $\hat{\beta}_1$ is 1.2581. The *t*-value of this estimated coefficient in this information regime is 29.3949, suggesting a remarkably strong statistical significance in the threshold regression model. In addition, this coefficient is larger than 1, indicating that financial analysts tend to underreact to stocks' extremely negative returns in making EPS forecasts in this information regime. In other words, even though a stock's past one-quarter returns fall into deep negative regime, financial analysts who follow the stock tend to be optimistic in forecasting the stock's next-quarter EPS.

Abarbanell (1991) and Lys and Sohn (1990) find that financial analysts underreact stocks' past returns, and our finding is in line with theirs when past one-quarter returns are in a negative regime. In the second information regime where past one-quarter returns are between −0.3968 and −0.2124, the estimated coefficient $\hat{\beta}_2$ is −0.1915 and statistically significant, according to the *t*-value of −5.5507. The negative slope exhibits an unusual pattern that is not reported in the literature yet. It suggests that financial analysts' EPS forecasts move in an opposite direction as the actual earnings do. In this sense, financial analysts are not efficient at all in making EPS forecasts when stocks' past one-quarter returns fall into an information regime where returns are negative but not extremely negative. In the third information regime−where past one-quarter returns are between −0.2124 and 0.3744, the estimated coefficient $\hat{\beta}_3$ is 1.0182, very close to 1. A further standard hypothesis testing of the null: $\hat{\beta}_3 = 1.0$, leads to a *p*-value of 0.2317. This means that the null hypothesis $\hat{\beta}_3 = 1.0$ cannot be rejected at 1 percent significance level. This result suggests that analysts are quite efficient and almost fully rational in making EPS forecasts in this information regime. Basu and Markov (2004), using a linear loss function to estimate the coefficient associated with stocks' past returns, report that financial analysts are rational when making EPS forecasts. In their study, a linear loss function allows a median-based unbiased estimation of the coefficients in a linear regression model since it removes the impact of the extreme values in stocks' past returns. In this study, the information regime of past one-quarter returns of $-0.2124 < r_{i,t-1} < 0.3744$ actually eliminates the extreme returns, either. And our result from using a conventional least square loss function in this regime points to the same evidence of financial analysts' high rationality as that reported by Basu and Markov (2004). It is worth noting that the *t*-value associated with the estimated coefficient in this regime is 66.9868, suggesting an extremely strong statistical significance of the coefficient. In the fourth regime where past one-quarter returns are greater than 0.3744, the estimated coefficient $\hat{\beta}_4$ is 0.0079, very small in its magnitude. Furthermore, the *t*-value associated with this coefficient is very small, as well. This suggests that this coefficient is not statistically significant and financial analysts do not efficiently react to stocks' extremely high past one-quarter returns in making EPS forecasts in this information regime.

Regarding the estimated coefficient $\hat{\gamma}_1$ associated with the past one-quarter return variable in the model (3), its *t*-value is 5.8571. This suggests that this variable is statistically significant in the model and indeed the past return information is used by financial analysts in making one-quarter ahead earnings forecasts.

5.2 *Financial analysts' rationality test based on past two-quarter return information*

Now we use past two-quarter returns right before the EPS forecasting quarter as the information variable. The threshold effects of this information variable are estimated using the model (3). Table IV reports the estimation results.

Table IV shows that at 1 percent significance level, the test statistics of the first and second threshold effects are much larger than the critical values, showing remarkably strong threshold effects. The test statistics of the third threshold effect is larger than the 5 percent critical value, suggesting that the third threshold exists, as well. Therefore three thresholds are identified when past two-quarter returns are used in the threshold regression model. Table V reports the estimation results based on the three identified thresholds.

The three estimated threshold values are $\hat{\omega}_1 = -0.3490$, $\hat{\omega}_2 = 0.0634$ and $\hat{\omega}_3 = 0.3518$, respectively. Correspondingly, the first structural break occurs when the past two-quarter return equals −0.3490, or −34.90 percent; the second structural break occurs when the past two-quarter return equals 0.0634, or 6.34 percent; the third structural break occurs when the past two-quarter return equals 0.3518, or 35.18 percent. Therefore there exist four information regimes in the past two-quarter returns. The estimated coefficient $\hat{\beta}_1$ in the first regime is 0.1737. In this regime, the past two-quarter returns are less than −0.3490. The *t*-value of this estimated coefficient is 5.9082, indicating that the coefficient is statistically significant. The magnitude of this estimated coefficient is much smaller than 1, suggesting that financial analysts are in a quite low efficiency when using the information of past two-quarter returns to make one-quarter ahead earnings forecasts in this information regime. It seems that financial analysts do not closely react to extremely negative returns information in a past-two-quarter time window. This pattern is very different from that observed in the first information regime when past one-quarter returns serve as the information variable. In the second return information regime where the past two-quarter returns are between −0.3490 and 0.0634, the estimated coefficient $\hat{\beta}_2$ is 1.0285, which is close to 1. A standard hypothesis testing of the null: $\hat{\beta}_2 = 1.0$, leads to a *p*-value of 0.1322. This indicates that the

Table IV.
Tests for threshold effects of past two-quarter returns

	Test for single threshold	Test for double thresholds	Test for triple thresholds
Test statistic, *F*	2,382.38	638.69	30.51
p-value	0.00	0.00	0.02
1% critical value	96.11	41.31	32.54
5% critical value	28.06	17.81	14.59
10% critical value	19.50	7.81	11.52

Table V.
Estimation results of the threshold model with three thresholds in past two-quarter returns

Coefficient	Estimate	SE	*t*-value
$\hat{\beta}_1$	0.1737	0.0294	5.9082
$\hat{\beta}_2$	1.0285	0.0189	54.4180
$\hat{\beta}_3$	0.9033	0.0199	45.3920
$\hat{\beta}_4$	0.0400	0.0073	5.4795
$\hat{\gamma}_1$	0.0223	0.0016	13.9375

Notes: This table reports the estimation results of the threshold model that identifies three thresholds in past two-quarter returns. The threshold regression model is in the form of:

$$\overline{AE}_{it} = \beta_1 \overline{FE}^t_{i,t-1} I(r_{i,t-1} \leqslant \omega_1) + \beta_2 \overline{FE}^t_{i,t-1} I(\omega_1 < r_{i,t-1} \leqslant \omega_2)$$

$$+ \beta_3 \overline{FE}^t_{i,t-1} I(\omega_2 < r_{i,t-1} \leqslant \omega_3) + \beta_4 \overline{FE}^t_{i,t-1} I(r_{i,t-1} > \omega_3) + \gamma_1 r_{i,t-1} + \bar{\varepsilon}_{it}$$

where $\overline{AE}_{it}$ and $\overline{FE}^t_{i,t-1}$ are demeaned actual and forecasted earnings, respectively; $r_{i,t-1}$ the past two-quarter return information of firm *i* during quarter *t*−1; ω_1, ω_2 and ω_3 the three thresholds in the model. The three estimated threshold values are:

$$\hat{\omega}_1 = -0.3490, \hat{\omega}_2 = 0.0634, \text{and } \hat{\omega}_3 = 0.3518$$

null hypothesis $\hat{\beta}_2 = 1.0$ cannot be rejected at 1 percent significance level. This suggests that financial analysts react to the past two-quarter returns in almost full rationality in the second return information regime. Furthermore, the t-value of 54.4180 shows that this coefficient is extremely significant in the threshold model. The estimated coefficient $\hat{\beta}_3$ in the third information regime, where the past two-quarter returns are between 0.0634 and 0.3518, is 0.9033, suggesting that financial analysts tend to slightly overestimate the one-quarter ahead earnings when using past two-quarter buy-and-hold return information. However, because the value of the estimated coefficient $\hat{\beta}_3$ is very close to 1, it shows that in this return information regime, financial analysts are highly rational in making one-quarter ahead earnings forecasts. In the fourth information regime where the past two-quarter returns are greater than 0.3518, the magnitude of the estimated coefficient $\hat{\beta}_4$ is very small. It indicates that when facing extremely positive past two-quarter returns, financial analysts do not efficiently incorporate the information in making one-quarter ahead earnings forecasts. This pattern is very similar to that observed when past one-quarter returns are used as the information variable in the threshold regression model. The t-value of the estimated coefficient $\hat{\gamma}_1$ is 13.9375, indicating that the past two-quarter return variable is statistically significant in the model and financial analysts do use the information in making one-quarter ahead earnings forecasts. This is in line with the findings in the existing literature.

5.3 Financial analysts' rationality test based on past four-quarter return information

To further investigate the impact of stocks' past returns on financial analysts' rationality in making earnings forecasts, we use past four-quarter returns as the information variable in the threshold regression model (3). Table VI presents the estimated threshold. Table VI shows that at 5 percent significance level, all the three thresholds are statistically significant. Therefore, in the past four-quarter returns, four information regimes are identified.

Table VII reports the estimation results for the thresholds and the coefficients in the threshold regression model. The three identified threshold values are $\hat{\omega}_1 = -0.4596$, $\hat{\omega}_2 = -0.1608$ and $\hat{\omega}_3 = -0.1166$, all of them are negative. This pattern of the structural breaks in the past four-quarter returns is distinctively different from those in the past one-quarter and two-quarter returns, as reported in Section 5.1 and 5.2, respectively. In the first return information regime where past the four-quarter returns are smaller than −0.4596, the estimated coefficient $\hat{\beta}_1$ is 0.2512. This coefficient, even though is statistically significant due to its large t-value, is much smaller than 1, indicating that financial analysts are at a very low efficiency level in using past four-quarter returns information for making one-quarter ahead earnings forecasts in this information regime. In other words, financial analysts do not significantly react to extremely negative past four-quarter returns in making EPS forecasts. In the second information regime where the past four-quarter returns are between −0.4596 and −0.1608, the estimated coefficient $\hat{\beta}_2$ is 1.2244, and the associated t-value is 43.0070. It suggests that financial analysts do use but do not fully use the past four-quarter returns information in making one-quarter ahead earnings forecasts in this information regime. Given that the coefficient is larger than 1, it indicates that financial analysts overestimate one-quarter ahead earnings in this information regime with

	Test for single threshold	Test for double thresholds	Test for triple thresholds
Test statistic, F	643.91	33.68	25.44
p-value	0.00	0.02	0.02
1% critical value	21.46	37.59	29.83
5% critical value	17.16	13.12	11.75
10% critical value	9.84	7.84	10.36

Table VI. Tests for threshold effects of past four-quarter returns

Coefficient	Estimate	SE	t-value
$\hat{\beta}_1$	0.2512	0.0302	8.3179
$\hat{\beta}_2$	1.2214	0.0284	43.0070
$\hat{\beta}_3$	0.8080	0.0513	15.7505
$\hat{\beta}_4$	1.0700	0.0175	61.1429
$\hat{\gamma}_1$	0.0128	0.0012	10.6667

Notes: This table reports the estimation results of the threshold model that identifies three thresholds in past four-quarter buy-and-hold returns. The threshold regression model is in the form of:

$$\overline{AE}_{it} = \beta_1 \overline{FE}^t_{i,t-1} I(r_{i,t-1} \leqslant \omega_1) + \beta_2 \overline{FE}^t_{i,t-1} I(\omega_1 < r_{i,t-1} \leqslant \omega_2) + \beta_3 \overline{FE}^t_{i,t-1} I(\omega_2 < r_{i,t-1} \leqslant \omega_3) + \beta_4 \overline{FE}^t_{i,t-1} I(r_{i,t-1} > \omega_3) + \gamma_1 r_{i,t-1} + \overline{\varepsilon}_{it}$$

where $\overline{AE}_{it}$ and $\overline{FE}^t_{i,t-1}$ are demeaned actual and forecasted earnings, respectively; $r_{i,t-1}$ the past four-quarter return information of firm i during quarter $t-1$; ω_1, ω_2 and ω_3 the three thresholds in the model. The three estimated threshold values are:

$$\hat{\omega}_1 = -0.4596, \hat{\omega}_2 = -0.1608, \text{and } \hat{\omega}_3 = -0.1166$$

Table VII. Estimation results of the threshold model with three thresholds in past four-quarter returns

extremely negative returns. However, in the third information regime where the past four-quarter returns are between −0.1608 and −0.1166, financial analysts underestimate one-quarter ahead EPS. This is because the estimated coefficient $\hat{\beta}_3$ is 0.8080, which is less than 1. The coefficient's t-value of 15.7505 indicates that it is statistically significant and financial analysts indeed use but do not fully use stocks' past four-quarter returns information in this regime. In the fourth information regime, the past four-quarter returns are greater than −0.1166. The corresponding estimated coefficient $\hat{\beta}_4$ is 1.0700. However, a standard hypothesis testing of the null: $\hat{\beta}_4 = 1.0$, generates a p-value of 0.000073. This indicates that the null hypothesis $\hat{\beta}_4 = 1.0$ can be rejected at 1 percent significance level. This suggests that in this information regime, financial analysts are not rational when making one-quarter ahead earnings forecasts. The estimated coefficient $\hat{\gamma}_1$ associated with the return variable is 0.0128, and is statistically significant due to a large t-value of 10.6667. Therefore, in all the four different information regimes, financial analysts are not rational when using past four-quarter returns information.

5.4 Rationality variation in different information regimes of past returns

Our results show that in all the three past returns with different lookback horizons, there exist structural changes, even though the thresholds turn out to have different values, respectively. This confirms the literature that there exist structural changes in stock returns (Schaller and Van Norden, 1997; Kim and Kon, 1999). From an economic perspective, the explanation to the structural changes in stock returns could point to macroeconomic and firm-specific factors: unexpected events in the market, extremely volatile moves, cyclical economic changes and firm-specific significant shocks could trigger structural changes in stock market returns. Furthermore, the results in this study support the hypothesis that in different information regimes, financial analysts' reactions to past returns vary. It is shown that financial analysts are not always fully rational in using stocks' past returns. In other words, financial analysts only logically use a certain range of stock return information. The explanation to these results is that financial analysts' forecasts of future EPS is a comprehensive decision-making process motivated by maximizing compensations, career advancement, good relationship to related brokerage firms, among other incentives. As such, when the information of stock returns has no negative impact on these incentives, financial analysts might fully incorporate the information in their EPS forecasts, otherwise, the information might not be fully reflected in EPS forecasts. Our results are in line with the findings by Easterwood and Nutt (1999), who point out that overestimation and underestimation of EPS by analysts are the result of a systematic optimism, which has been reported in the literature. Furthermore, our finding that in some range of stocks' past returns financial analysts are rational but in other ranges they are not supports the inefficiency theory in the literature. Additional explanation to our results is that when a stock market is in volatile time period, stock returns experience extraordinary fluctuations, making financial analysts harder to incorporate the unusual information into their forecasting models for EPS, leading to lower level of rationality or efficiency.

The results further show that the ranges of the information regimes where financial analysts behave rationally are different when the lookback time windows for the past returns are different. In the past one-quarter return case, the rationality is observed in the range of (−0.2124, 0.3744), and this range in the past two-quarter case becomes (−0.3490, 0.0634), which is narrower than that in the past one-quarter case. Furthermore, in the past four-quarter case, there is no rationality regime at all. These results show that when a lookback time window is one-quarter, the rationality regime is the widest, followed by a narrower rationality regime in the two-quarter lookback time window, and then the rationality regime disappears in the four-quarter lookback time window. This distinctive tendency revealed from our results indicates that when the past stock return information has a longer lookback horizon, financial analysts use the information less and less efficiently. Raedy *et al.* (2006) report that financial analysts' reactions to earnings-related information in making EPS forecasts depend on information horizon. Our results are in line with this finding. An additional explanation is that, the more distant the information horizon is, the less accurate the information is, and as such, financial analysts would be less efficient in using the information.

6. Conclusions

This research studies whether and how structural changes in stocks' past returns impose significant impacts on financial analysts' earnings forecasts. Specifically, we aim to answer a research question:

RQ. Whether financial analysts are homogeneously rational in using stocks' past returns information.

Past one-quarter, two-quarter, and four-quarter buy-and-hold returns immediately prior to the quarter during which earnings forecasts are made are treated as the information variable. Structural changes in stocks' past returns are tested using a threshold regression model that allows simultaneous estimation of both threshold and slope coefficients. The results show that three significant structural breaks and four respective information regimes are identified in stocks' past returns. Across the four different information regimes, financial analysts react to past returns quite differently when making one-quarter ahead earnings forecasts. When using past one-quarter return information to make earnings forecasts, financial analysts are almost fully rational when the returns are between −0.2124 and 0.3744. Financial analysts' full rationality is observed when the returns are between −0.3490 and 0.0634 when past two-quarter return information is used to make EPS forecasts. However, when the buy-and-hold return time window is increased to past four quarters, financial analysts do not show any rationality in making earnings forecasts. In this sense, depending on the length of past time horizon, financial analysts react quite differently to stocks' past return information. It appears that financial analysts tend to be rational in a larger range of returns when more recent information of past returns are used. For example, the range of past returns leading to financial analysts' full rationality is the largest when past one-quarter returns are used, and the range becomes zero when past four-quarter returns are used. Even though financial analysts' reaction to the information of past returns remarkably vary in different return information regimes, the estimation results from the threshold regression model show that past returns is a statistically significant factor in earnings forecasts.

The findings from this study are in line with those reported in the existing literature that financial analysts have asymmetric reactions to past returns information when making earnings forecasts. Adding to the existing literature, this study further identifies the different return information regimes where the rationality of financial analysts would change in making earnings forecasts.

7. Implications, limitations and future research

The results from this study have several implications. To researchers, this study adds more insights into the research on financial analysts' behavior in making EPS forecasts. Specifically, using a threshold regression model makes it possible to reveal the different reactions of financial analysts in the different structures of stocks' past returns. Methodologically, this study provides a different quantitative approach on testing financial analysts' rationality in making EPS forecasts. The finding that financial analysts are only rational when using a certain range of stock return information calls for more research on the reasons behind this behavior. From a practical perspective, the findings from this study may help practitioners in the equity investment field better use the EPS forecasts provided by financial analysts. Put it more concretely, it is helpful to be aware that EPS forecasts could be overestimated or underestimated when stock returns are extremely negative. The risk level of an investment portfolio based on forecasted EPS information might not reflect the true risk exposure. Furthermore, financial analysts' recommendations on stocks could be impacted by biased EPS forecasts. In addition, a trading strategy that is built up on the basis of EPS forecasts needs to be adjusted when a structural change in stock returns is detected.

There are several limitations in this study. First, it only considers the US stock market, which is highly efficient. In many emerging markets, the information flow might not be very transparent and market manipulation imposes significant impact on equity trading and influences financial analysts' EPS forecasts. Studying financial analysts' rationality in these emerging markets is important and can add new insights into the field of behavioral finance. Second, in this study, we did not consider the (possible) impact of the 1987 stock market crash and the 2008 financial market crisis on the rationality test. During these two financial market crashes, many stock returns were extremely negative. As such, the structural changes in stock returns could be impacted by these events.

Future research will use return volatility as the information variable in the threshold regression model to test whether volatility exists any structural change. And if there is structural change in stock volatility, what is its impact on financial analysts' rationality in making earnings forecasts will be the focus of future study. Furthermore, future research will explore the relationship between financial analysts' EPS forecasting bias and structural changes in stock returns.

Note

1. Q3 of 1984 is the earliest available time for each firm included in this study for the EPS data in I/B/E/S.

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About the author

Zhixin Kang is Associate Professor of Quantitative Methods at the Department of Economics and Decision Sciences – University of North Carolina at Pembroke. His research has been published in *Communications in Statistics – Theory and Methods*, *Journal of Real Estate Finance and Economics*, *Statistics and Its Interface*, *Journal of Real Estate Portfolio Management*, *Journal of Transnational Management*, *Applied Financial Economics*, *International Journal of Supply Chain and Inventory Management*, *International Journal of Electronic Finance*, *Scholarship and Practice of Undergraduate Research*, etc. Zhixin Kang can be contacted at: zhixin.kang@uncp.edu