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A Multifactor Explanation of Post-Earnings Announcement Drift

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Abstract

To explain post-earnings announcement drift, we construct a risk factor related to unexpected earnings surprise, and propose a four-factor model by adding this risk factor to Fama and French's (1993), (1995) three-factor model. This earnings surprise risk factor provides a remarkable improvement in explaining post-earnings announcement drift when included in addition to the three factors of Fama and French. After adjusting raw returns for the four risk factors, the cumulative abnormal returns over the 60 trading days subsequent to quarterly earnings announcements are economically and statistically insignificant. Furthermore, except for the first two days after the earnings announcement, the cumulative abnormal returns and the arbitrage returns from our four-factor model are relatively stable over the testing period and never significant on any day of the testing period. On the other hand, the arbitrage returns from the other models increase over the 60-day testing period. We argue that most of the post-earnings announcement drift observed in prior studies may be a result of using misspecified models and failing to appropriately adjust raw returns for risk.

I. Introduction

Ball and Brown (1968) document that a systematic relationship between current unexpected earnings and stock returns continues even after earnings are announced. This relation implies that earnings information already publicly available can be used to predict abnormal stock returns, a phenomenon termed post-earnings announcement (PEA) drift, which is a violation of the (semi-strong) efficient market hypothesis. Specifically, the estimated cumulative abnormal returns continue to drift up (down) for firms having actual earnings greater (less) than expected earnings, even after earnings are announced. By constructing decile standardized unexpected earnings (SUE) portfolios, Foster, Olsen, and Shevlin (FOS) (1984) show that this systematic drift of returns continues over the 60 trading

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days after the quarterly earnings announcements. That is, the cumulative abnormal returns (CAR) on the portfolios with more positive (negative) SUE continue to increase (decrease) even after the earnings information becomes public.

Since Ball and Brown (1968), a body of literature has developed on documenting and explaining the positive relation between the sign and magnitude of the unexpected earnings and stock returns over the trading days subsequent to earnings announcements. More recently, Bernard and Thomas (BT) (1989) examine two possible explanations for this phenomenon: mispricing and CAPM misspecification. They find that neither the shifts in market beta from the CAPM model nor the five risk factors of the APT model suggested by Chen, Roll, and Ross (CRR) (1986) is able to explain the PEA drift. Since both models fail to provide support for the missing risk factor explanation for the PEA drift, BT conclude that the drift is a phenomenon due to the market's delayed response.[1] However, the fact that this drift is robust over a long period of time (both during BT's sample period, 1974–1986, and our sample period, 1984–1999) suggests that the PEA drift may in fact be a phenomenon consistent with equilibrium pricing (BT briefly implied this possibility in their conclusion section). It is possible that the models used by BT can be misspecified in calculating abnormal returns and, therefore, they might fail to appropriately adjust raw returns for risk. Thus, it is premature to dismiss the explanations based on equilibrium risk factor models such as the CAPM or CRR-style APT model.

Fama and French (FF) (1993), (1995) departing from the one-factor CAPM model, show that average stock returns co-vary with three factors, namely, the market risk factor, the book-to-market factor, and the size factor. Further, FF (1996) show that many existing capital market anomalies, namely, size, book-to-market, E/P (earnings to price ratio), and C/P (cash flow to price ratio) anomalies, are explained by their three-factor model, except for the short-term momentum returns documented by Jegadeesh and Titman (1993). Motivated by this failure, Carhart (1997) includes a risk factor capturing Jegadeesh and Titman's short-term momentum anomaly in FF's three-factor model and explains the persistence of returns of equity mutual funds.

Extending the above multifactor approaches, we identify and develop a risk factor that provides an incremental explanation for the PEA drift after controlling for the firm's information environment. The risk factor we develop in this paper is related to the notion that investors know that there will be a possible surprise compared to the expected earnings when the next period's earnings are announced. The fact that the stock price will respond positively (negatively) to *unexpectedly* higher (lower) earnings than the expected earnings in the next period (earnings surprise), in conjunction with uncertainty about the direction of the surprise, causes current period investors to face the risk of an unexpected earnings surprise for the next period.

[1]Rendleman, Jones, and Latane (1987) conclude that the PEA drift is rather a pre-announcement adjustment to next quarter's earnings after examining the subsequent period's SUEs. Extending this finding, subsequent studies argue that the PEA drift is either a result of the market's ignoring or underestimating the serial correlation in the SUEs (Bernard and Thomas (1990), Ball and Bartov (1996)) and therefore not reflecting fully the implications of current earnings for future earnings, or a result of the investors' revising their earnings expectation as more transparent information is released after earnings are announced (Soffer and Lys (1999)).

The degree of the risk of an unexpected earnings surprise will be conditional upon the firm's information environment, because the stock price response to the unexpected earnings surprise can be different according to the degree of information uncertainty. Imhoff and Lobo (1992) show that the return response to unexpected earnings is more sensitive for firms with a more transparent information environment. The intuition is that when a firm's unexpected negative (positive) earnings surprise hits the market, investors would be *more* disappointed (pleasantly surprised) if the information environment of the firm were more transparent and, therefore, they would react more negatively (positively) than if the information environment were more uncertain. By the same token, investors of firms with more uncertain information environments would be better prepared for any earnings surprises; therefore, they would not react as strongly as the investors of firms with transparent information environments. We use the standard deviation of analysts' earnings forecasts as the proxy for the degree of earnings information uncertainty.

Our paper has two objectives. First, we develop a common risk factor unconditional on information uncertainty by subtracting returns on the negative earnings surprise portfolio from returns on the positive earnings surprise portfolio, as in FF. This risk factor is the return on a zero-investment portfolio that captures risk due to the unexpected earnings surprise; we call it the earnings surprise (ES) risk factor. Secondly, by adding this risk factor into FF's well-known three-factor model, we suggest a four-factor model to explain the PEA drift. The earnings surprise is measured by the difference between actual earnings and the average of analysts' earnings forecasts that proxy for the market expectation. Since the momentum effect in stock returns (Jegadeesh and Titman (1993)) might be related to the PEA drift because both earnings and price convey information on the company's future cash flow in different forms, we add the momentum risk factor suggested by Carhart (1997) into FF's three-factor model and compare the results with those from our four-factor model.[2]

We find that our four-factor model explains the PEA drift fairly well. When the ES risk factor is added to FF's three-factor model, there is a remarkable improvement in explaining the PEA drift. That is, after adjusting for the four risk factors, the (cumulative) arbitrage returns over the 60 trading days subsequent to the quarterly earnings announcements are economically and statistically insignificant. The arbitrage returns from FF's three-factor model, however, are still significant. When the momentum risk factor is added into FF's three-factor model, the arbitrage returns are similar to those from FF's three-factor model. Moreover, when this momentum risk factor is added into our four-factor model, the marginal improvement in explaining the PEA drift is negligible.

The paper is organized as follows: Section II describes the data, and Section III explains in detail how to construct the risk factor representing the unexpected earnings surprise and proposes a four-factor model. Section IV describes the process of constructing SUE portfolios, Section V presents the empirical results, and Section VI concludes.

[2]We appreciate the referee's suggestion.

II. Data

Quarterly earnings forecasts by financial analysts are obtained from the 2000 I/B/E/S tape. Forecast data and actual earnings information to compute the ES factor are retrieved from the Summary Tape and the Detail Tape, respectively. Firms with less than three earnings forecasts are not included because we use the standard deviation of earnings forecasts (dispersion) as a measure of the degree of information uncertainty. We use the standard deviation of forecasts made in the final month of the firms' fiscal quarter for which earnings forecasts are made. The magnitude of the earnings surprise is determined by measuring the difference between the actual earnings obtained from I/B/E/S and the average of analysts' earnings forecasts. A total of 106,808 firm-quarter earnings observations (6,735 firms) are retrieved over the period 1984–1999.

When computing the standardized unexpected earnings (SUE) to construct portfolios, we use actual quarterly earnings data obtained from COMPUSTAT Quarterly Industrial, Full Coverage, and Research files covering 22 years (or 88 quarters). Quarterly earnings announcement dates are also obtained from the COMPUSTAT files. Stock return data are obtained from the CRSP daily return file. After combining the I/B/E/S data, COMPUSTAT data, and CRSP stock return data, we obtain 88,619 firm-quarter observations (5,741 firms) over the period October 1984–December 1999.

Of these 88,619 firm-quarter observations, we exclude those that do not have the SUE value. The computation of the SUE in each quarter requires at least 16 quarters of earnings data during the past six years (24 quarters). We also exclude the quarterly earnings announcements if the firm is initially listed or delisted over the 60 trading days before and after the announcement date. The final sample contains 60,715 firm-quarter observations. The CRSP NYSE/Amex/NASDAQ value-weighted index is used as the market index. By using daily returns on all firms listed in NYSE/Amex/NASDAQ, we construct the SMB and HML portfolios according to FF (1993).

III. The Earnings Surprise Risk Factor and a Four-Factor Model

In this section, we explain how we construct the risk factor representing the unexpected earnings surprise. At the beginning of a given calendar month (January, April, July, or October) over the period October 1984–December 1999, we form five portfolios of information environment by assigning firms to one of the five portfolios based on the magnitude of the standard deviation (divided by stock price per share) of analysts' earnings forecasts for the most recent quarter. The standard deviation of analysts' forecasts is our proxy for the firms' information environment. Firms having zero standard deviation of forecasts are assigned to portfolio 1 and considered to have the most transparent information environment. The remaining firms with non-zero standard deviation of analysts' forecasts are equally assigned to one of the four quartile portfolios—portfolios 2 through 5—in an ascending order. We call these five portfolios the *D*-matrix. Thus, *D*-matrix portfolio 5 contains firms with the largest standard deviation of earnings forecasts and therefore the most uncertain information environment.

Within a particular D-matrix portfolio, at the given calendar month (January, April, July, or October), firms are then reassigned to one of the three earnings surprise portfolios according to the difference between actual earnings and average analysts' earnings forecast for the most recent quarter $(q - 1)$. If a firm's actual earnings are less than, equal to, or greater than the average forecast, the firm is assigned to the negative, zero, or positive earnings surprise portfolio, respectively. Fifteen (5×3) portfolios are, therefore, formed. Daily returns on each of the 15 portfolios are maintained from two days after the next quarter's (q) earnings announcement day $(t = +2)$ to one day after the following quarter's $(q + 1)$ earnings announcement day $(t = +1)$. The reason for this holding period is that since most firms usually announce earnings after the close of the market $(t = 0)$, investors are able to know the composition of the new portfolios after the close of the market and to buy/sell stocks to rebalance portfolios during the next day $(t = +1)$. Thus, newly rebalanced portfolios begin two days after the earnings announcement $(t = +2)$ and end one day after the next quarter's earnings announcement $(t = +1)$. Portfolio returns are then computed with equal weights.

In each D-matrix portfolio, we subtract returns on the negative earnings surprise portfolio from returns on the positive earnings surprise portfolio. The resulting portfolio is a zero-investment portfolio that represents the earnings surprise risk factor conditional on a given information uncertainty category. Then we take the equally weighted average of returns on these five zero-investment portfolios. This is the unconditional earnings surprise (ES) risk factor.

Table 1 shows the basic statistics of the 15 portfolios from October 1984 through December 1999: average daily returns, standard deviations of daily returns, amount of earnings surprise (divided by stock price per share), standard deviation of analysts' earnings forecasts (divided by stock price per share), firm size, and book-to-market ratios.[3] Table 1 shows that the earnings surprise risk premium (or the difference between the average returns on the positive ES portfolio and the negative ES portfolio) is highest when earnings information uncertainty is least opaque, and this risk premium almost monotonically decreases with earnings information uncertainty. That is, the daily ES risk premium is 0.095% in D-matrix portfolio 1 (with zero standard deviation of analysts' forecasts), while it is 0.026% in D-matrix portfolio 5 (with the largest standard deviation of analysts' forecasts). These results imply that investors who hold stocks for which analysts' earnings forecasts for the next period are uniform could face the highest ES risk and thus require the highest risk premium. The reason is that, despite the analysts' uniform consensus regarding the firm's earnings for the next period, when actual earnings are diverged from the consensus (even in a small amount), investors will react more drastically to an unprepared earnings surprise. On the other hand, when the analysts' forecasts are diverged, investors will react less excessively because they are to some extent prepared for this deviation.

[3]The stock price provided in I/B/E/S is used in dividing earnings data.

TABLE 1

Basic Statistics of the Portfolios for Earnings Surprise (ES) Risk Factor (October 1984–December 1999)

	Avg. Ret. (%)					Std. Dev. (%)				
Portfolio	(−)	(0)	(+)	Diff. (+) − (−)	Whole	(−)	(0)	(+)	Diff. (+) − (−)	Whole
1	0.062	0.128	0.157	0.095	0.123	1.339	1.109	1.478	1.261	1.332
2	0.028	0.042	0.065	0.037	0.046	0.840	0.950	0.933	0.400	0.872
3	0.039	0.071	0.081	0.042	0.070	0.846	1.015	0.891	0.426	0.901
4	0.048	0.078	0.080	0.032	0.065	0.902	1.116	0.978	0.705	0.885
5	0.072	0.130	0.098	0.026	0.083	0.970	1.429	0.977	0.583	0.926
Avg.	0.044	0.088	0.103							
	(Earnings Surprise/ Price) × 100					(Std. Dev. of Analysts' EPS Forecasts/ Stock Price) × 100				
1	−0.581	0.000	0.196			0.000	0.000	0.000		
2	−0.267	0.000	0.148			0.059	0.050	0.051		
3	−0.434	0.000	0.256			0.118	0.099	0.104		
4	−0.703	0.000	0.365			0.217	0.185	0.196		
5	−2.289	0.000	1.090			0.859	0.521	0.703		
	Firm Size ($million)					Book-to-Market				
1	1,344	4,008	2,406			0.510	0.407	0.513		
2	3,441	4,535	3,675			0.571	0.483	0.640		
3	2,155	2,211	2,511			0.736	0.587	0.709		
4	1,718	1,509	2,042			0.720	0.669	0.823		
5	881	768	1,207			0.801	0.698	0.902		
	Avg. Sample Size (per quarter)									
1	41	90	80							
2	102	59	142							
3	131	46	139							
4	155	34	129							
5	219	19	120							

At each quarter, portfolios are formed by the standard deviation of analysts' earnings forecasts divided by stock price (five portfolios) and then by the sign of the difference between actual earnings and average forecasted earnings (or earnings surprise) (three portfolios). Portfolio 1 is the portfolio of firms with zero standard deviation of analysts' earnings forecasts, and portfolios 2–5 are the quartile portfolios of firms with non-zero standard deviation of analysts' earnings forecasts. Portfolio 2 (5) is the portfolio of firms with the smallest (largest) non-zero standard deviation of forecasts. The notations (−), (0), and (+) indicate negative, no, and positive earnings surprise portfolios, respectively.

Our four-factor time-series model extends FF's three-factor model by adding the ES risk factor as follows,

$$(1) \quad R_{it} - R_{ft} \quad = \quad \alpha_i + \beta_{1i}(R_{mt} - R_{ft}) + \beta_{2i}\mathrm{SMB}_t + \beta_{3i}\mathrm{HML}_t + \beta_{4i}\mathrm{ES}_t + \varepsilon_{it},$$

where R_{it} is the return on a portfolio on day t, R_{ft} is the one-month Treasury bill's daily yield, and R_{mt} is the return on the CRSP value-weighted portfolio of all NYSE, Amex, and NASDAQ stocks. SMB and HML are the returns on FF's zero-investment portfolios, representing the size and book-to-market factors respectively, and ES is the returns on the zero-investment portfolio, representing the unexpected earnings surprise factor.

Table 2 summarizes the average, standard deviation, and (cross-) autocorrelation of the explanatory (daily) returns on the four risk factor portfolios plus the risk factor portfolio related to Jegadeesh and Titman's (1993) momentum effect that serve as the independent variables in the time-series regressions; the market risk factor $(R_{mt} - R_{ft})$, SMB, HML, ES, and the momentum risk factor.[4] The average return on each of the risk factor portfolios is the risk premium per unit of the factor's systematic risk. The average return of the ES risk factor over the sample period is relatively higher than that of the other factors; it is 0.0449% per day, while the average returns of the market factor, SMB, and HML are 0.0535%, 0.0016%, and 0.0109% per day, respectively.[5] The average return of the momentum risk factor is 0.0322% per day. The correlation coefficients of the ES risk factor with the other factors are not high, indicating that the ES risk factor is not much overlapped with the other factors and is not simply a replication of the other factors. Furthermore, the low magnitude of the lagged cross-autocorrelation of the ES risk factor with the other factors also supports the above argument. The correlation coefficient between the ES and momentum risk factors is low (0.169), while the correlation coefficients between the momentum risk factor and the other risk factors are relatively high (0.317, −0.320, and −0.240 with the market risk factor, SMB, and HML, respectively).

TABLE 2

Average Returns, Standard Deviations, and Correlation Coefficients of the Risk Factors (October 1984–December 1999)

Panel A. Average Returns and Standard Deviations

	Avg. Ret. (%)	Std. Dev. (%)	*t*-Stat.
$R_{mt} - R_{ft}$	0.0535	0.8845	3.99
SMB	0.0016	0.5534	0.19
HML	0.0109	0.4310	1.67
ES	0.0449	0.5042	5.52
Momentum	0.0322	0.6045	3.30

Panel B. Correlation and Cross-Autocorrelation Coefficients

	$R_{mt} - R_{ft}$ (0)	SMB(0)	HML(0)	ES(0)	Momentum (0)	$R_{mt} - R_{ft}$ (0)	SMB(0)	HML(0)	ES(0)	Momentum (0)
	$(\rho(k=0))$					$\rho(k=1)$				
$R_{mt} - R_{ft}(-k)$	1.000	−0.472	−0.609	0.221	0.317	0.095	0.306	−0.074	0.038	−0.036
SMB$(-k)$	−0.472	1.000	0.073	−0.102	−0.320	−0.095	−0.003	0.063	−0.083	−0.111
HML$(-k)$	−0.609	0.073	1.000	−0.202	−0.240	−0.077	−0.210	0.220	−0.033	−0.024
ES$(-k)$	0.221	−0.102	−0.202	1.000	0.169	0.045	0.027	−0.050	0.191	0.067
Momentum$(-k)$	0.317	−0.320	−0.240	0.169	1.000	0.056	0.026	−0.082	0.066	0.267
	$\rho(k=2)$					$\rho(k=3)$				
$R_{mt} - R_{ft}(-k)$	−0.028	0.110	0.036	−0.051	−0.093	−0.040	0.119	0.044	−0.057	−0.111
SMB$(-k)$	0.025	0.033	−0.014	−0.025	−0.012	0.016	0.001	−0.027	−0.010	−0.008
HML$(-k)$	−0.022	−0.055	0.056	0.059	0.022	0.042	−0.096	−0.007	0.055	0.070
ES$(-k)$	−0.006	0.011	0.005	0.011	0.034	0.028	0.013	−0.051	−0.003	0.026
Momentum$(-k)$	0.005	−0.035	0.004	0.010	0.093	−0.024	−0.014	0.030	0.008	0.021

R_{mt}	CRSP value-weighted market daily returns
R_{ft}	one-month Treasury bill daily yield
SMB	Fama-French's (1993) risk factor related with firm size
HML	Fama-French's (1993) risk factor related with book-to-market
ES	earnings surprise risk factor
Momentum	risk factor related to the momentum effect (based on the previous one year's return) constructed similarly to Carhart (1997)
$\rho(k)$	the *k*th lagged cross-autocorrelation coefficient between $X(-k)$ and $X(0)$ risk factors.

[4]The momentum risk factor is constructed in a similar manner to that used in Carhart (1997) as the value-weighted average return of firms with the highest 30% past 11-month returns lagged one month minus the value-weighted average return of firms with the lowest 30% past 11-month returns lagged one month. The portfolios include all NYSE stocks and are re-formed monthly.

[5]The small magnitude of the average SMB is related to the phenomenon that firm size effect is much weakened and even insignificant post-1980.

IV. Constructing SUE portfolios

To examine whether our four-factor model explains the PEA drift, we construct 10 SUE portfolios as in FOS (1984). At a given quarter q, we determine the cut-off point for each portfolio based on the previous quarter's $(q-1)$ distribution of SUEs, and assign firms to one of the SUE decile portfolios according to the quarter's (q's) SUE values. The reason why we use the previous quarter's cut-off points and not the current quarter's is to avoid the bias of using hindsight information (FOS (1984)). Portfolio 1 (portfolio 10) contains firms having the most negative (positive) SUEs. The SUE of a firm i in quarter q is computed as

$$\text{SUE}_{i,q} = \frac{Q_{i,q} - E(Q_{i,q})}{\sigma(Q_{i,q} - E(Q_{i,q}))}, \tag{2}$$

where $Q_{i,q}$ is quarterly actual earnings of firm i in quarter q, and $E(Q_{i,q})$ is the estimated quarterly earnings of firm i in quarter q, and $\sigma(\cdot)$ is the standard deviation of the forecast errors. To obtain $E(Q_{i,q})$, we first estimate the following AR(1) process by using the most recent 24 quarters' observations,[6]

$$Q_{i,q} - Q_{i,q-4} = \phi_{i0} + \phi_{i1}(Q_{i,q-1} - Q_{i,q-5}) + \varepsilon_{i,q}. \tag{3}$$

The estimated earnings are then calculated as $E(Q_{i,q}) = Q_{i,q-4} + \hat{\phi}_{i1}(Q_{i,q-1} - Q_{i,q-5}) + \hat{\phi}_{i0}$. We also compute the estimated quarterly earnings from the random walk process as $E(Q_{i,q}) = Q_{i,q-4} + \hat{\phi}_{i0}$. Since the overall results are not qualitatively different, we report the results based only on the AR(1) process.

V. Results

A. Descriptive Results

Table 3 presents the average SUEs, standard deviation of analysts' earnings forecasts (EPSSTD divided by stock price), earnings surprise (divided by stock price per share), firm size, and book-to-market ratios across the 10 SUE portfolios. Portfolios 1–5 have negative SUEs, while portfolios 6–10 have positive SUEs. The average SUEs of the two middle portfolios are smallest in absolute magnitude. The standard deviation of analysts' earnings forecasts of the two middle portfolios are also smallest in absolute magnitude, forming a U-shape over the magnitude of the SUE. That is, when analysts' forecasts are more diverged, the absolute magnitude of SUE is greater. The analysts' forecast error (or the earnings surprise) and the SUE almost move in the same direction. However, their signs of the analysts' forecast error and SUE are not consistent in some portfolios, and their relation is not linear. There is no pattern in terms of firm size and book-to-market over the SUE portfolios.

[6]We require at least 16 quarters' observations when all 24 quarters' data are not available.

TABLE 3

Basic Statistics of SUE Decile Portfolios (October 1984–December 1999)

SUE Portfolio	SUE	(EPSSTD/P) ×100	(EE/P) ×100	Firm Size ($million)	BM
1	−3.874	0.473	−1.943	3,568	0.630
2	−1.031	0.335	−0.563	3,523	0.631
3	−0.504	0.425	−0.402	3,573	0.642
4	−0.224	0.281	−0.227	3,554	0.641
5	−0.045	0.254	−0.143	3,383	0.635
6	0.097	0.237	−0.019	3,954	0.661
7	0.250	0.253	−0.013	4,168	0.653
8	0.461	0.281	−0.009	4,115	0.674
9	0.864	0.271	0.079	3,282	0.686
10	2.375	0.504	0.012	3,383	0.695

At a given quarter, we determine cut-off points based on the previous quarter's SUEs and assign firms to one of the SUE decile portfolios. SUE is the standardized unexpected earnings (see Section IV for the detailed computational method). EPSSTD is the standard deviation of analysts' EPS forecasts, EE is the difference between actual EPS and the mean analysts' forecasted EPS, and P is stock price per share.

B. Explaining Post-Earnings Announcement Drift by the Four-Factor Model

Direct evidence as to whether a risk factor captures a part of the common variations in returns would be demonstrated by the significance of sensitivity of asset returns to the risk factor or the slope coefficient on the risk factor in the time-series regressions. The intercept in each time-series regression model, a measure of abnormal returns, reflects whether a factor model appropriately captures the mean return of an asset. Since our main interest is to explain the PEA drift, we examine, as a preliminary test, whether FF's three-factor model, our four-factor model, and another four-factor model with FF's three factors plus the momentum risk factor, appropriately capture the common risk structure in returns after a quarterly earnings announcement. To test the ability of each model to explain the PEA drift, we estimate the three- and four-factor models using the daily returns over the 60 trading days subsequent to the earnings announcement for each quarterly earnings announcement (total 60,715 firm-quarters). We then assign the coefficient estimates to one of the 10 SUE portfolios as explained above.

Panel A of Table 4 presents the averages of the time-series regression coefficients of FF's three-factor model and their t-statistics in each of the 10 SUE portfolios. The variance of the resulting time-series estimated coefficients is used to determine the standard error of the average. The slope estimates on the three factors are all significant as expected. The intercept estimates are also all significant at a 5% level except for portfolio 6. Furthermore, there is a monotonic pattern in the intercept estimates across the SUE portfolios. The greater the SUE, the greater the intercept estimate (or the abnormal returns). This evidence indicates that FF's three-factor model is not sufficient to capture the abnormal pattern of the post-earnings announcement returns.

Panel B of Table 4 shows the estimation results of the four-factor model with FF's three factors plus the momentum factor. The intercept estimates are also all statistically significant except for portfolios 4 and 6, although the absolute magnitude of the intercept estimates is slightly smaller than in FF's three-factor model.

We also estimate our four-factor model with FF's three factors plus the ES risk factor and present the results in panel C of Table 4. The slope coefficient estimates of the earnings surprise (ES) risk factor are all significant. Even with the addition of the ES risk factor, moreover, the slope estimates on the other three factors are not significantly changed in magnitude and statistical significance. This implies that the explanatory power of the ES factor is not overlapped with that

TABLE 4

Averages of the Regression Coefficients of the Excess Daily Returns of the SUE Portfolios on the Risk Factors over the 60 Trading Days after a Quarterly Earnings Announcement

Panel A. $R_{it} - R_{ft} = \alpha_i + \beta_{1i}(R_{mt} - R_{ft}) + \beta_{2i}\text{SMB}_t + \beta_{3i}\text{HML}_t + \varepsilon_{it}$

SUE Portfolio	$\overline{\hat{\alpha}}_i$	$\overline{\hat{\beta}}_{1i}$	$\overline{\hat{\beta}}_{2i}$	$\overline{\hat{\beta}}_{3i}$	Sample Size
1	−0.000172 (−3.76)	1.129 (89.35)	0.518 (33.18)	0.103 (4.89)	6025
2	−0.000112 (−2.66)	1.099 (94.71)	0.473 (33.30)	0.114 (5.84)	6114
3	−0.000182 (−4.49)	1.109 (100.79)	0.492 (34.84)	0.135 (7.32)	6178
4	−0.000081 (−1.97)	1.077 (91.59)	0.464 (32.38)	0.177 (9.62)	6019
5	−0.000081 (−2.04)	1.102 (95.38)	0.450 (32.27)	0.196 (11.00)	6074
6	0.000050 (1.37)	1.095 (106.62)	0.436 (34.48)	0.194 (11.63)	6130
7	0.000151 (3.94)	1.092 (100.19)	0.437 (33.25)	0.151 (8.90)	6016
8	0.000134 (3.62)	1.090 (104.02)	0.423 (32.86)	0.111 (6.52)	6068
9	0.000224 (5.80)	1.129 (99.65)	0.499 (35.54)	0.117 (6.47)	6046
10	0.000190 (4.46)	1.141 (95.45)	0.507 (35.33)	0.109 (5.67)	6045

Panel B. $R_{it} - R_{ft} = \alpha_i + \beta_{1i}(R_{mt} - R_{ft}) + \beta_{2i}\text{SMB}_t + \beta_{3i}\text{HML}_t + \beta_{5i}\text{Momentum}_t + \varepsilon_{it}$

SUE Portfolio	$\overline{\hat{\alpha}}_i$	$\overline{\hat{\beta}}_{1i}$	$\overline{\hat{\beta}}_{2i}$	$\overline{\hat{\beta}}_{3i}$	$\overline{\hat{\beta}}_{5i}$	Sample Size
1	−0.000157 (−3.44)	1.120 (86.88)	0.454 (27.63)	0.037 (1.76)	−0.146 (−11.07)	6025
2	−0.000099 (−2.31)	1.087 (91.23)	0.414 (28.06)	0.060 (3.05)	−0.128 (−10.15)	6114
3	−0.000185 (−4.54)	1.106 (96.42)	0.452 (30.22)	0.108 (5.50)	−0.115 (−9.56)	6178
4	−0.000054 (−1.24)	1.088 (90.07)	0.417 (27.80)	0.146 (7.62)	−0.139 (−11.62)	6019
5	−0.000087 (−2.16)	1.092 (91.65)	0.414 (28.34)	0.155 (8.34)	−0.080 (−7.04)	6074
6	0.000067 (1.84)	1.082 (102.23)	0.404 (30.88)	0.169 (9.85)	−0.033 (−3.07)	6130
7	0.000161 (4.15)	1.077 (96.52)	0.392 (28.94)	0.115 (6.51)	−0.051 (−4.69)	6016
8	0.000126 (3.34)	1.087 (100.03)	0.406 (29.87)	0.108 (6.14)	−0.024 (−2.17)	6068
9	0.000217 (5.51)	1.119 (96.85)	0.472 (32.01)	0.100 (5.39)	−0.019 (−1.74)	6046
10	0.000187 (4.29)	1.121 (91.72)	0.464 (31.26)	0.079 (3.98)	−0.053 (−4.38)	6045

(continued on next page)

TABLE 4 (continued)

Averages of the Regression Coefficients of the Excess Daily Returns of the SUE Portfolios on the Risk Factors over the 60 Trading Days after a Quarterly Earnings Announcement

Panel C. $R_{it} - R_{ft} = \alpha_i + \beta_{1i}(R_{mt} - R_{ft}) + \beta_{2i}\text{SMB}_t + \beta_{3i}\text{HML}_t + \beta_{4i}\text{ES}_t + \varepsilon_{it}$

SUE Portfolio	$\overline{\hat{\alpha}}_i$	$\overline{\hat{\beta}}_{1i}$	$\overline{\hat{\beta}}_{2i}$	$\overline{\hat{\beta}}_{3i}$	$\overline{\hat{\beta}}_{4i}$	Sample Size
1	−0.000133	1.143	0.519	0.086	−0.144	6025
	(−2.81)	(88.49)	(32.46)	(4.01)	(−5.63)	
2	−0.000070	1.103	0.468	0.101	−0.123	6114
	(−1.62)	(92.09)	(32.18)	(5.12)	(−5.27)	
3	−0.000157	1.115	0.493	0.125	−0.099	6178
	(−3.74)	(98.05)	(34.26)	(6.56)	(−4.05)	
4	−0.000043	1.083	0.466	0.169	−0.079	6019
	(−1.00)	(90.50)	(32.14)	(9.04)	(−3.39)	
5	−0.000078	1.105	0.452	0.192	−0.034	6074
	(−1.91)	(92.50)	(31.98)	(10.53)	(−1.55)	
6	0.000011	1.086	0.441	0.207	0.077	6130
	(0.29)	(103.83)	(34.47)	(12.26)	(3.76)	
7	0.000128	1.079	0.433	0.159	0.084	6016
	(3.23)	(97.70)	(32.57)	(9.26)	(4.05)	
8	0.000070	1.071	0.430	0.129	0.153	6068
	(1.85)	(100.56)	(33.11)	(7.50)	(7.27)	
9	0.000144	1.095	0.498	0.135	0.212	6046
	(3.46)	(95.18)	(34.93)	(7.45)	(9.64)	
10	0.000134	1.107	0.506	0.136	0.188	6045
	(3.03)	(91.58)	(34.78)	(7.00)	(7.64)	

At each quarterly earnings announcement, excess daily returns on each of the 10 SUE portfolios are regressed on the risk factors over the period from $t = 0$ to $t = 60$ after earnings announcement. All quarterly earnings announcements (60,715 firm-quarter observations) from October 1984–December 1999 are examined. The averages of the regression coefficient estimates are computed, and t-statistics are computed by dividing the averages by their standard errors. t-statistics are presented in parentheses. R_{mt} is the value-weighted market return, R_{ft} is the one-month Treasury bill daily yield, SMB and HML are Fama and French's (1993) risk factors related with firm size and book-to-market, Momentum is Carhart's (1997) risk factor related with the momentum effect, and ES is the earnings surprise risk factor. The sample size is the number of the time-series risk factor model estimation for each earnings announcement in the portfolio.

of the three factors, and the ES factor is an independent and separate explanatory variable. The slope estimates on the ES factor exhibit a monotonic pattern with the magnitude of the SUE. The returns on the negative (positive) SUE portfolios are negatively (positively) sensitive to the ES factor. More importantly, the intercept estimates are much less statistically significant than those of FF's three-factor model or the four-factor model with the momentum factor; only five portfolios have significant intercept estimates at the 5% significance level. Furthermore, the magnitude of the intercept estimates is much smaller. It is evident, therefore, that by adding the ES risk factor we have obviously improved FF's three-factor model for the purpose of explaining the significant abnormal returns of the SUE portfolios.[7]

To examine more direct evidence that the four-factor model explains the PEA drift, we compute the abnormal returns generated from our four-factor model over the 60 trading days ($t = +1$ to $+60$) subsequent to the quarterly earnings announcement. We call these 60 trading days ($t = +1$ to $+60$) the testing period. In addition, we compute the abnormal returns from the other models: market-

[7]We also estimated a five-factor model with FF's three factors, the momentum factor, and the ES risk factor. The magnitude of the intercept estimates is similar to that from our four-factor model. However, seven intercept estimates among the 10 are statistically significant. The detailed results are available upon request.

adjusted, size-adjusted, CAPM one-factor-adjusted, FF's three-factor-adjusted, the four-factor-adjusted (FF's three factors plus the momentum risk factor), and five-factor-adjusted (FF's three factors, the momentum factor plus the ES factor). The abnormal returns are computed as follows,

$$\text{AR}_{it} = R_{it} - E(R_{it}), \tag{4}$$

where AR_{it} is the abnormal return for firm i on day t, R_{it} is the raw return for firm i on day t, and $E(R_{it})$ is the expected return for firm i on day t. For the market-adjusted abnormal returns, returns on the CRSP value-weighted portfolio of all NYSE, Amex, and NASDAQ stocks are used for $E(R_{it})$. To compute the size-adjusted abnormal returns, returns on the NYSE/Amex/NASDAQ size decile portfolio, of which firm i is a member at the beginning of the calendar year, are used for $E(R_{it})$. Note that the CRSP market portfolio and the firm size decile portfolios are companion portfolios, not the risk factors. For the abnormal returns from the one-factor CAPM model,[8] FF's three-factor model, the four-factor model, and the five-factor model, we estimate the factor loadings (or the beta coefficients) of the models using 60 daily returns ($t = -60$ to -1) prior to the quarterly earnings announcements, and apply the estimated factor loadings to compute $E(R_{it})$ for the testing period.

For each of the 60,715 quarterly earnings announcements, we compute the cumulative raw returns and the CARs from each model over the testing period. Then we assign these returns to one of the 10 SUE portfolios, as explained in the previous section. Table 5 reports the averages of the cumulative raw returns and the CARs from each of the five models on portfolio 10 (P10; with the largest SUE) and portfolio 1 (P1; with the smallest SUE), and the difference in the averages between portfolio 10 and portfolio 1 (P10−P1) on t = +1, +2, +5, +10, +20, +30, +40, and +60.[9]

The cumulative raw (risk-unadjusted) returns on the two extreme portfolios, P10 and P1, over the testing period are 4.75% and 3.44%, respectively. The difference between P10 and P1 (i.e., the arbitrage return over 60 post-earnings announcement trading days on a zero-investment portfolio by taking a long position in stocks of P10 and a short position in stocks of P1) is 1.31%. They are all statistically significant at the conventional significance level. Furthermore, the arbitrage return of 1.31% per quarter (or 5.24 per year, approximately) is economically significant. These cumulative raw returns and the arbitrage return will be a benchmark in our analysis in examining how much of these returns can be captured by the companion portfolios or the risk factors.

The market- and size-adjusted CARs, which are the companion portfolio-adjusted CARs, are much smaller than the cumulative raw returns. For example, the market-adjusted CARs on P10 and P1 are 0.79% and −0.60%, respectively. More importantly, however, the (cumulative) arbitrage returns are still statistically significant and of similar magnitude to the arbitrage returns of risk-unadjusted

[8]In the one-factor market model, we estimate the market beta by using the OLS and Scholes and Williams' approach (1977). The results are similar. Therefore, only the results by Scholes and Williams are reported.

[9]We report the results for the two extreme portfolios. The results of portfolios 2–9 are also available upon request.

case; they are 1.39% and 1.34% per quarter, respectively. Even after adjusting for the one-factor market risk, the arbitrage return is still similar; it is 1.35% per quarter (with t-statistics of 1.97). This result indicates that the CAPM fails to explain the anomaly related to the PEA drift.

With the addition of the SMB and HML risk factors to the market risk factor (FF's three factors), there is a little improvement in explaining the PEA drift. FF's three-factor-adjusted arbitrage return over the testing period is 1.13% per quarter (with t-statistics of 1.97). However, it is still economically and statistically significant. When the ES risk factor is added to FF's three factors, we find an obvious improvement in explaining the PEA drift. Table 5 shows that the CARs from our four-factor model (with FF's three factors plus the ES factor) on P10 and P1 over the testing period are only 0.32% (with t-statistics of 0.54) and -0.25% (with t-statistics of -0.88) per quarter, respectively. They are not statistically significant. The arbitrage return is also insignificant; it is 0.57% (with t-statistics of 0.92) per quarter. The annualized arbitrage return is approximately 2% only. Therefore, the economic significance of this arbitrage return is negligible after considering some transaction costs.

Table 5 also shows that the momentum risk factor does not play a pivotal role in explaining the PEA drift. For example, the CAR over the testing period from the four-factor model with the addition of the momentum risk factor into FF's three factors is still relatively large; it is 1.04% (with t-statistic of 1.59) per quarter. Furthermore, when the momentum risk factor is added into our four-factor model, the CAR is 0.55% (with t-statistic of 0.90) per quarter. This is a negligible improvement from the 0.57% per quarter of our four-factor model, implying that the momentum risk factor has almost no marginal explanatory power for the PEA drift.

There are more remarkable findings in our four-factor-adjusted arbitrage returns over the testing period. First, the CARs and arbitrage returns stay relatively stable over the entire testing period except for the first two days after the earnings announcement $(t = +1, +2)$. As Table 5 shows, however, the CARs and arbitrage returns from the other models increase over time.[10] Secondly, most of the arbitrage returns actually occur on day 1 $(t = +1)$. Without day 1 returns, the arbitrage returns over the 60 post-earnings announcement trading days would be negligible. In fact, most firms usually announce earnings after the market closes for the day. The stock price on the announcement day therefore does not fully reflect the earnings information, and stock price up to the next day $(t = +1)$ could adjust fully for the new information regarding earnings. The arbitrage returns on day 1 from the other models are also similar, whether or not risk factors are adjusted. Overall, the results support our argument that, after controlling for the firms' information environment, our four-factor model almost completely explains PEA drift.

[10] Bernard and Thomas (1989), however, also observe that a disproportionately large amount of the 60-day drift occurs within the five days after the earnings announcement. For example, they report that 20% of the 60-day drift for large firms occurs during the five-day period.

TABLE 5

Cumulative Abnormal Returns (CAR) (%) of the SUE Decile Portfolios Estimated by Various Factor Models (October 1984–December 1999)

		Days after Quarterly Earnings Announcement							
		+1	+2	+5	+10	+20	+30	+40	+60
Cum.	P10	0.30*	0.32*	0.51*	1.22*	2.20*	2.85*	3.29*	4.75*
raw		(4.69)	(3.64)	(3.61)	(6.13)	(7.80)	(8.27)	(8.26)	(9.73)
return	P1	−0.10	−0.01	0.24	0.85*	1.57*	2.01*	2.25*	3.44*
		(−1.51)	(−0.10)	(1.60)	(4.03)	(5.29)	(5.53)	(5.36)	(6.68)
	P10−P1	0.40*	0.33*	0.27	0.37	0.63	0.84	1.04*	1.31*
		(4.63)	(2.76)	(1.42)	(1.38)	(1.64)	(1.80)	(1.96)	(2.01)
Market-	P10	0.24*	0.23*	0.17	0.40	0.71*	0.72*	0.62	0.79
adj.		(3.68)	(2.46)	(1.16)	(1.93)	(2.40)	(1.99)	(1.49)	(1.55)
CAR	P1	−0.16*	−0.11	−0.13	0.03	0.00	−0.26	−0.58	−0.60
		(−2.65)	(−1.26)	(−0.91)	(0.13)	(0.01)	(−0.78)	(−1.48)	(−1.26)
	P10−P1	0.40*	0.34*	0.30	0.37	0.71	0.98*	1.20*	1.39*
		(4.52)	(2.66)	(1.48)	(1.33)	(1.77)	(2.00)	(2.11)	(2.10)
Size-	P10	0.24*	0.23*	0.20	0.40*	0.80*	0.89*	0.96*	1.00*
adj.		(3.83)	(2.61)	(1.42)	(2.00)	(2.84)	(2.57)	(2.41)	(2.49)
CAR	P1	−0.16*	−0.09	−0.08	0.06	0.12	−0.02	−0.22	−0.34
		(−2.88)	(−1.18)	(−0.67)	(0.32)	(0.48)	(−0.07)	(−0.61)	(−0.23)
	P10−P1	0.40*	0.33*	0.28	0.34	0.68	0.91*	1.18*	1.34*
		(4.51)	(2.58)	(1.42)	(1.21)	(1.71)	(1.98)	(2.08)	(2.04)
CAPM-	P10	0.23*	0.22*	0.14	0.30	0.54	0.45	0.33	0.45
adj.		(3.70)	(2.43)	(0.98)	(1.49)	(1.92)	(1.29)	(0.83)	(0.92)
CAR	P1	−0.18*	−0.13	−0.18	−0.06	−0.15	−0.38	−0.77*	−0.90*
		(−3.02)	(−1.55)	(−1.34)	(−0.32)	(−0.55)	(−1.18)	(−2.07)	(−1.95)
	P10−P1	0.41*	0.35*	0.32	0.36	0.69	0.83	1.11*	1.35*
		(4.69)	(2.78)	(1.60)	(1.29)	(1.75)	(1.72)	(1.98)	(1.97)
FF 3-	P10	0.23*	0.19*	0.09	0.19	0.43	0.37	0.30	0.32
factor		(3.79)	(2.29)	(0.70)	(1.03)	(1.61)	(1.14)	(0.81)	(0.69)
adj. CAR	P1	−0.18*	−0.13	−0.17	−0.05	−0.01	−0.16	−0.56	−0.82*
		(−3.28)	(−1.68)	(−1.36)	(−0.26)	(−0.02)	(−0.53)	(−1.68)	(−1.99)
	P10−P1	0.41*	0.32*	0.26	0.24	0.44	0.53	0.86	1.13*
		(4.65)	(2.62)	(1.34)	(0.86)	(1.11)	(1.11)	(1.73)	(1.97)
FF +	P10	0.23*	0.19*	0.09	0.22	0.43	0.41	0.41	0.47
Momentum		(3.93)	(2.36)	(0.66)	(1.15)	(1.76)	(1.37)	(1.12)	(1.03)
4-factor	P1	−0.18*	−0.12	−0.17	−0.08	−0.04	−0.12	−0.46	−0.57
adj. CAR		(−3.56)	(−1.84)	(−1.75)	(−0.60)	(−0.10)	(−0.32)	(−1.38)	(−1.54)
	P10−P1	0.41*	0.32*	0.26	0.30	0.47	0.53	0.86	1.04
		(4.88)	(2.68)	(1.49)	(1.10)	(1.23)	(1.15)	(1.61)	(1.59)
FF +	P10	0.23*	0.19*	0.09	0.20	0.44	0.36	0.29	0.32
ES		(4.02)	(2.38)	(0.68)	(1.10)	(1.73)	(1.21)	(0.88)	(0.54)
4-factor	P1	−0.19*	−0.14*	−0.15	0.02	0.12	0.07	−0.23	−0.25
adj. CAR		(−3.61)	(−1.99)	(−1.32)	(0.11)	(0.53)	(0.33)	(−0.69)	(−0.88)
	P10−P1	0.42*	0.33*	0.24	0.22	0.32	0.29	0.52	0.57
		(5.07)	(2.81)	(1.28)	(0.73)	(0.86)	(0.64)	(0.99)	(0.92)
FF + ES	P10	0.23*	0.19*	0.07	0.22	0.47	0.42	0.36	0.36
+ Momentum		(4.14)	(2.42)	(0.59)	(1.24)	(1.94)	(1.46)	(1.06)	(0.90)
5-factor	P1	−0.18*	−0.13*	−0.14	−0.03	0.09	0.10	−0.18	−0.19
adj. CAR		(−3.87)	(−2.03)	(−1.28)	(−0.15)	(0.58)	(0.54)	(−0.55)	(−0.47)
	P10−P1	0.41*	0.32*	0.22	0.25	0.36	0.31	0.54	0.55
		(5.27)	(2.85)	(1.29)	(0.81)	(1.03)	(0.72)	(1.09)	(0.90)

P10 and P1 are the largest (tenth) SUE and smallest (first) SUE portfolios among the decile portfolios, respectively. P10−P1 is the difference between the CARs of the largest and smallest SUE portfolios, which is an arbitrage return on a zero-investment portfolio. The estimation period for the factor loadings (or betas) of FF's three-factor and our four-factor models is from $t = -60$ to $t = -1$ prior to a quarterly earnings announcement, and the market beta of the CAPM-adjusted model is Scholes-Williams' beta estimate. * is significant at the 5% significance level. t-statistics are presented in parentheses. FF three-factors are Fama and French's (1993) $R_{mt} - R_{ft}$, SMB and HML. Momentum is the risk factor related with the momentum effect, and ES is the earnings surprise risk factor.

VI. Concluding Remarks

To explain the post-earnings announcement drift, we construct a risk factor related to unexpected earnings surprise, and propose a four-factor model by adding this risk factor to Fama and French's (1993), (1995) well-known three-factor model. When this earnings surprise risk factor is added to Fama and French's three factors, there is a remarkable improvement in explaining the post-earnings announcement drift. That is, after adjusting for the four risk factors, the cumulative arbitrage return over the 60 trading days subsequent to a quarterly earnings announcement is economically and statistically insignificant. The (cumulative) arbitrage returns from Fama and French's three-factor model, as well as from the other models, however, are still significant.

Another notable finding is that, except for the first two days after the earnings announcement, the CARs and arbitrage returns from our four-factor model are relatively stable over the testing period and never significant on any day of the testing period. On the other hand, the CARs and arbitrage returns from the other models increase over time.

Based on the above finding that the four-factor model proposed in this paper explains the post-earnings announcement drift fairly well, we argue that most of the post-earnings announcement drift documented by prior studies may result from the use of misspecified models and the failure to appropriately adjust raw returns for risk. Our study could be extended to identify the nature and extent of the risk factor—the earnings surprise factor—developed in this paper. Although it makes intuitive sense that investors will face the risk of predicting the future earnings surprise, whether this risk changes as more information on future earnings becomes available, and if so, how this change will affect the stock price, are topics for future research.

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