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Rest in Peace Post-Earnings Announcement Drift

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ABSTRACT

This paper revisits price formation following earnings announcements. In modern financial markets, stock prices fully reflect earnings surprises on the announcement date, leading to the disappearance of post-earnings announcement drifts (PEAD). For large stocks, PEAD have been non-existent since 2006 but has only disappeared recently for microcap stocks. PEAD remain a prevalent area of study in finance and accounting despite having largely disappeared. This paper concludes with a set of recommendations for researchers who conduct such studies to better assess the existence of PEAD and suggests future research avenues to examine price formation following earnings news.

Keywords: Earnings Announcements, Market Efficiency, Post-Earnings Announcement Drifts, Price Discovery

JEL Codes: G10, G12, G14

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Price formation to firm earnings news has been subject to a large body of work since the study of Ball and Brown (1968) and is commonly associated with post-earnings announcement drifts (PEAD), that is, the tendency of stock prices to slowly incorporate earnings news over multiple days or months. The comprehensive summary of PEAD documented in Ball and Brown (1968), Jones and Litzenberger (1970), and Foster *et al.* (1984), and Bernard and Thomas (1989) led to a spur of studies examining factors contributing to the persistence of this anomaly over so many years. The persistence in PEAD is generally attributed to trading frictions impeding the price discovery process such as transaction costs (Bhushan, 1994; Ng *et al.*, 2008), arbitrage risks (Mendenhall, 2004), illiquidity (Chordia *et al.*, 2009), and limited investor attention (DellaVigna and Pollet, 2009; Hirshleifer *et al.*, 2009).

Figure 1 reports the number of articles published in top finance and accounting journals per year retrieved from Web of Science related to PEAD – for a total of 183 articles. The figure shows PEAD remain a subject of interest among academics that has yet to dissipate. Just in the last five years, 58 articles related to PEAD were published.

With the recent rise in information production, the decrease in trading cost, and the increased spending in price discovery (see, Bai *et al.*, 2016; Farboodi *et al.*, 2021), few studies have examined the evolution of how efficiently stock markets incorporate earnings news into stock prices. Understanding how effectively financial markets conduct price discovery at the time of news announcements is fundamental to evaluating models of price formation in financial economics.

In this paper, I revisit price formation following earnings news with the aim to (*i*) determine whether stock prices incorporate public infor-

Chapman, Kevin Crotty, Olivier Dessaint, Adlai Fisher, Mike Gellemeyer, Andrey Golubov, Vincent Grégoire, Dale Griffin, Michael Hasler, Terry Hendershott, Jiri Knesl, Ali Lazrak, Jiasun Li, Andrew Lo, Russell Lundholm, Ryan Riordan, Mike Simutin, Kumar Venkataraman, Yan Xiong, and seminar participants at the UBC Finance and Accounting divisions, the Vancouver School of Economics, HEC Montréal, University of Virginia, Temple University, University of Colorado Boulder, Nanyang Technology University, University of Melbourne, University of Toronto Finance and Accounting divisions, Rice University, McGill University, Binghamton SUNY, and CICF 2018 for their comments and suggestions. Abdennour Aissaoui provided excellent research assistance. I acknowledge financial support from the Montreal Exchange (Bourse de Montréal), Bank of Montreal Capital Group, Canadian Securities Institute Research Foundation, and the Social Sciences and Humanities Research Council of Canada (SSHRC).

mation (earnings surprises) more quickly on the announcement date and (ii) whether there is still evidence of post-earnings announcement drifts. The cumulative evidence shows striking evidence that stock prices have become more efficient following earnings announcements. Prices on announcement date reflect earnings news more quickly, leading to the disappearance of PEAD. My results emphasize market efficiency is not static but dynamic, continuously adapting to changes in the environment of financial markets[1] and present a set of recommendations to future studies examining price formation following earnings news.

I first carry out the empirical analysis examining price drifts at the daily frequency following earnings announcements after conditioning on *analyst* earnings surprises (i.e., the difference between announced earnings and expected earnings by analysts). I graphically depict the cumulative returns following earnings announcements over 60 trading days and present evidence that price drifts gradually disappear over time. In recent years, I find no evidence of slow price formation following earnings announcements. I further show that the decline in price drifts is not related to more efficient price discovery prior to earnings announcements as *pre*-announcement drifts have also significantly weakened over time.

I then examine separately price discovery for stocks with market capitalization greater than the NYSE 20th percentile ("all-but-microcap" stocks) and stocks with market capitalization smaller than the NYSE 20th percentile (microcap stocks). It is well known that price drifts are more persistent for small stocks in part because they are more costly to trade (Bhushan, 1994; Chordia *et al.*, 2009). Prices of all-but-microcap and microcap stocks are respectively six and three times more responsive to earnings surprises on announcement date in the latter part of the sample (2016-2019) than in the early part of the sample (1984-1990). A weakening in pre-announcement drifts does not explain the improvement in the response of announcement date returns to earnings surprises. Moreover, since 2006, I show, analyst earnings surprises fail to positively predict post-announcement returns over 60 days for all-but-microcap stocks, and since 2016 for microcap stocks. In addition, PEAD does not now hide in more "subtle" ways, e.g., PEAD is not present for the smallest "all-but-microcap" stocks and at shorter horizon. To put it differently, all of the price discov-

[1] These findings are consistent with the adaptive market hypothesis (see Lo, 2017, for an excellent overview of the adaptive market hypothesis).

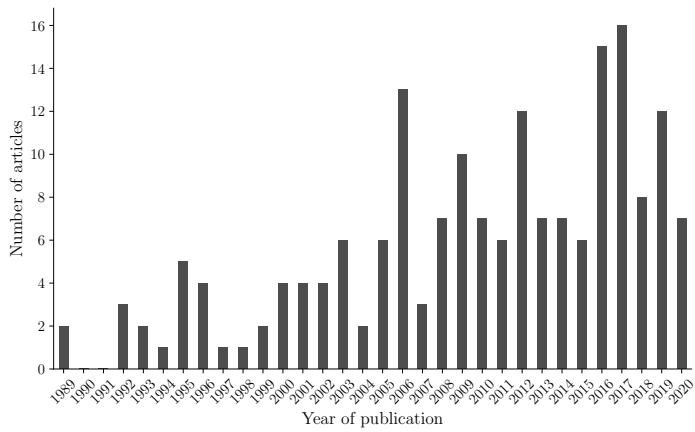

Figure 1: The number of published papers related to post-earnings announcement drifts

Description: This figure shows the number of published papers from 1989 to 2020 (October) related to post-earnings announcement drifts in high-ranked finance and accounting journals reported in Web of Science. The high-ranked finance journals are the Journal of Finance, Journal of Financial Economics, Review of Financial Studies, Journal of Financial and Quantitative Analysis, and the Review of Finance. The high-ranked accounting journals are the Journal of Accounting Economics, Journal of Accounting Research, The Accounting Review, Review of Accounting Studies, and Contemporary Accounting Research. I also include Management Science. The search words used to retrieved the articles are (post-earnings announcement drift OR announcement drift OR price formation) AND earnings.

ery after conditioning on analyst surprises now occurs at the time of the announcement.

I then study price formation after conditioning on random-walk earnings surprises (i.e., the simple difference between announced earnings and earnings of the prior year of the same quarter). Compared to analyst surprises, random-walk earnings surprises is a much noisier measure of earnings news to explain price reaction to earnings announcements. Nonetheless, random-walk surprises are commonly used in the literature as not all stocks have analysts following and this more than doubles the earnings announcement sample size. This increase in the number of earnings announcements, however, is mostly concentrated in microcap stocks. For all-but-microcap stocks, random-walk earnings surprises only predict positively returns following announcements prior to 1990. For microcap stocks, random-walk surprises continue to positively predict post-announcement returns; however, the persistence in drifts does not last more than five days. Also, for microcap stocks with analyst coverage, the ability of random-walk earnings surprises to predict returns over time is more sporadic and statistically weak.

These results are consistent with the findings of Hou *et al.* (2020). Examining long-short portfolios on various stock characteristics, the authors find microcap stocks account for many of the published anomalies and suggest multiple ways to mitigate microcap stocks' effect as they represent only 3.2% of the aggregate market capitalization but 60.7% of the number of stocks. Similarly, I find any remaining evidence of PEAD is generally driven by microcap stocks with poor information environment (e.g., no analysts coverage).

My findings further suggest recommendations to future studies examining price formation at the daily horizon following earnings announcements. First, it is recommended to study price formation over different periods. I show that aggregating long time-series can highlight the presence of market inefficiencies when, in recent years, such inefficiencies have vanished. Second, researchers should use analyst earnings surprise instead of random-walk surprises because analyst surprises better explain price reaction to earnings news and minimize the effect of microcap stocks. When the analysis is conducted using random-walk surprises, it increases the number of earnings announcements significantly, but this increase primarily comprises of microcap stocks with no analyst following. Consequently, OLS regressions tend to put more weights on

outliers with volatile returns, which most likely are microcap stocks (Hou *et al.*, 2020). Finally, with price discovery now generally occurring on the announcement date, it encourages future studies to examine the role of frictions (e.g., transaction costs, investor attention) in price discovery around earnings announcements using intraday data.[2] On that last point, I further show using unbiasedness regressions that announcement date prices for all-but-microcap stocks better reflect one-quarter ahead prices over time such that announcement date prices are now martingale. This entails price drifts following earnings announcements are generally absent and reinforce the need to examine the intraday dynamics of price formation to earnings news on the day of the announcement.

This paper complements recent studies documenting an attenuation in return predictability of pricing anomalies, which they attribute to better liquidity, hedge fund activities, and academic research (Chordia *et al.*, 2014; McLean and Pontiff, 2016; Calluzzo *et al.*, 2019). Their conclusions are based on the decline in long-short portfolio trading strategies' profitability at the *monthly* horizon. Still, these studies do not examine how price discovery changes around the release of public information at the *daily* horizon and when price discovery takes place. Moreover, I examine the evolution in price formation dynamics following earnings announcements at the individual stock level and show that price discovery mainly takes place *on* the day of the announcement. Finally, the studies cited above focus only on random-walk surprises when examining return predictability following earnings announcements. I present results for both analyst and random-walk earnings surprises and show how these measures can lead to different conclusions regarding the price formation process.

1 Overview of the Literature

Academic interests about price formation following earnings news remains a popular topic in the finance and accounting literature. To present an overview of this literature's importance in academic finance and accounting, I retrieve from Web of Science all published articles containing the following search criteria (post-earnings announcement drift OR announcement drift OR price formation) AND earnings. I then restrict the search

[2]For recommendations on how to conduct such studies using intraday data, see Grégoire and Martineau (2021).

to the following leading journals in finance and accounting: The Journal of Finance, Journal of Financial Economics, Review of Financial Studies, Journal of Financial and Quantitative Analysis, The Review of Finance, Journal of Accounting Economics, Journal of Accounting Research, The Accounting Review, Review of Accounting Studies, Contemporary Accounting Research, and Management Science. I retrieve a total of 183 articles as of October 2020. This total number of articles represents a lower bound of the general interest towards this topic. A simple search on the Social Science Research Network (SSRN) with "post-earnings announcement drifts" as search words returns a total of 296 papers.

Figure 1 shows the number publication per year and Table 1 reports the number of articles per outlet. Among the 183 articles, 72 (39%) and 105 (57%) articles are published in finance and accounting journals, respectively. The remaining six (4%) articles are published in Management Science. Among the finance journals, the journal with the most publication is The Journal of Finance with 23 articles, followed by the Journal of Financial Economics with 17 articles and the Review of Financial Studies with 15 articles. The leading three accounting journals, The Accounting Review, Journal of Accounting and Economics, and Journal of Accounting Research published 24, 23, and 22 articles, respectively. Among 183 articles, I select empirical studies that directly examine the link between earnings surprises and stock returns following earnings announcements, for a total of 80 articles.[3] Table A.1 in the Appendix list the papers, with the corresponding authors, the publication outlet, the main friction under investigation, the earnings surprise measure(s) used, whether authors consider individual stock-level returns or long-short portfolio returns, and the sample period.

The majority of the articles (70 out 80) listed in Table A.1 examine individual stock-level returns (e.g., buy-and-hold returns or cumulative returns) following earnings announcements as opposed to long-short portfolios (i.e., buy stocks with high positive earnings surprises and short-sell stocks with high negative earnings surprises in the prior month). The decay in long-short returns profitability at the monthly horizon has been documented in Chordia *et al.* (2014) and McLean and Pontiff (2016), and

[3] I exclude papers that are primarily theory, broad surveys of the literature, focus only on earnings announcement date returns, treat PEAD as a control variable, and where the earnings surprise measure is the announcement date return.

Field:	Finance		Accounting		Other	
	Journal	N.	Journal	N.	Journal	N.
	JF	23	TAR	24	MS	6
	JFE	17	JAE	23		
	RFS	15	JAR	22		
	JFQA	13	RAS	20		
	RF	4	CAR	16		
Total		72		105		6

Table 1: The number of published papers related to post-earnings announcement drifts per journal outlet

Description: This table reports the number of published papers from 1989 to 2020 (October) related to post-earnings announcement drifts in high-ranked finance and accounting journals retrieved from Web of Science. The high-ranked finance journals are the Journal of Finance (JF), Journal of Financial Economics (JFE), Review of Financial Studies (RFS), Journal of Financial and Quantitative Analysis (JFQA), and the Review of Finance (RF). The high-ranked accounting journals are the Journal of Accounting Economics (JAE), Journal of Accounting Research (JAR), The Accounting Review (TAR), Review of Accounting Studies (RAS), and Contemporary Accounting Research (CAR). I also include Management Science (MS). The search words used to retrieved the articles are (post-earnings announcement drift OR announcement drift OR price formation) AND earnings.

Calluzzo *et al.* (2019). However, it is yet clear whether price discovery generally occurs at the time of the announcement or over several days following earnings announcements. This paper sheds light on this issue. Despite evidence of decay in long-short portfolio return profitability, it is evident from Figure 1 that PEAD remain a popular research topic.

The main trading frictions that are commonly examined known to impede the price discovery process are transaction costs (Bhushan, 1994; Ng *et al.*, 2008), arbitrage risks (Mendenhall, 2004), illiquidity (Chordia *et al.*, 2009), and limited investor attention (e.g., DellaVigna and Pollet, 2009; Hirshleifer *et al.*, 2009). For such frictions to impede price discovery, the underlying mechanism of price discovery that some of these papers assume is that prices reflect earnings news through the arrival of trades as in the seminal model of Kim and Verrecchia (1994).[4] In today's financial markets, however, liquidity providers are mostly high-frequency traders and largely responsible for adjusting prices to public information using limit orders without trading (see Brogaard *et al.*, 2019); diminishing the importance of trading frictions impeding price discovery. Over the period of 2011 to 2015, Grégoire and Martineau (2021) present direct evidence of price discovery following earnings surprises mostly occurring through changes in quotes and not through trading, even in highly illiquid markets (i.e., the after-hours market). Thus, today's liquidity providers are now much more sophisticated at processing news and adjusting quoted prices accordingly, which can explain, among other reasons, why price discovery of earnings news is expected to occur more quickly.

2 Data

2.1 Earnings announcements

In this paper, I use two earnings announcement samples: the first consists of firms with reported earnings in Compustat (the "Compustat sample"),

[4]In classical microstructure models, price discovery of private information occurs through the arrival of trades (Glosten and Milgrom, 1985; Kyle, 1985). Despite the news being public information, Kim and Verrecchia (1994) models liquidity providers as incapable of processing earnings news and rely on the arrival of trades from sophisticated traders that can process earnings news to adjust prices accordingly. Studies examining the role of trading following earnings announcements include Bhattacharya (2001), Battalio and Mendenhall (2005), and Bhattacharya *et al.* (2007), and Ayers *et al.* (2011).

and the second is the same set of firms but with at least one analyst earnings forecast in I/B/E/S (the "I/B/E/S sample"). The main difference between both samples is that stocks in I/B/E/S have at least one analyst forecast. For the construction of both samples, I follow Livnat and Mendenhall (2006) and impose the following selection criteria for each firm earnings announcement j for firm quarter q:

1. The earnings announcement date is reported in Compustat.
2. The price per share is available from Compustat as of the end of quarter q and is greater than \$1, and the stock market capitalization is greater than \$5 million.
3. The firm's shares are traded on the New York Stock Exchange (NYSE), American Stock Exchange, or NASDAQ.
4. Accounting data are available to assign the stock to one of the 25 size and book-to-market Fama-French portfolios using the NYSE breakpoints.

The sample periods for the Compustat sample and the I/B/E/S sample begin in 1973 and 1984, respectively, and both end on December 31, 2019.[5] The total number of earnings announcements is 593,654 for the Compustat sample (with non-missing random-walk earnings surprises defined in the next section) and 312,462 for the I/B/E/S sample. Figure 2 shows the number of unique firms per year and the total number of earnings announcements for both samples and captures the rise and fall in the number of U.S. publicly listed firms (see Doidge *et al.*, 2017).

2.2 Estimating earnings surprises

I compute two measures of earnings surprises (the "news"). The first measure is the analyst earnings surprise. Following Livnat and Mendenhall (2006) and Hartzmark and Shue (2018), I define analyst earnings surprises as

$$\text{Analyst surprise}_{i,j,t} = \frac{EPS_{i,j,t} - E_{t-1}[EPS_{i,j,t}]}{P_{i,j,t-5}}, \tag{1}$$

[5]The sample coverage in I/B/E/S starts in 1983, but only a limited number of firms are covered in I/B/E/S and meet the selection criteria.

where $EPS_{i,j,t}$ is firm i's earnings per share of quarterly earnings announcement j announced on day t, and $E_{t-1}[EPS_{i,j,t}]$ is the expected earnings per share, measured by the consensus analyst forecast. I define the consensus analyst forecast as the median of all analyst forecasts issued over the 90 days before the earnings announcement date. If analysts revise their forecasts during this interval, I use only their most recent forecasts. I scale the surprise by the firm's stock price ($P_{i,j,t-5}$) five trading days before the announcement and winsorize earnings surprises at the 1st and 99th percentiles.

Table 2 reports the summary statistics for analyst earnings surprises, in percent, for all-but-microcap and microcap stocks for different periods since 1984. All-but-microcap and microcap stocks are those with market capitalization above and below the NYSE 20th percentile, respectively. The table shows the mean (median) earnings surprise is negative (positive) over the years. Notably, the inter-quartile range (75th-25th percentile) is wider for small than large stocks. The distribution of earnings surprises is more negatively skewed in the earlier part of the sample and becomes less skewed in recent years; this change in skewness is more evident in Figure 3, Panel A. This figure shows the median and the 10th-90th percentile range of earnings surprises. The distribution of earnings surprises remains stable from 1995 to 2019, except when it widened significantly during the financial crisis of 2008.

Panel B of Figure 3 shows the median and the 10th-90th percentile range of analyst forecast dispersion since 1984. Forecast dispersion is commonly used as a measure of investor disagreement about future earnings. I measure forecast dispersion in expected earnings as

$$\text{Dispersion}_{i,j,t} = \frac{\sqrt{V_{t-1}[EPS_{i,j,t}]}}{|E_{t-1}[EPS_{i,j,t}]|}, \tag{2}$$

where V_{t-1} is the variance of all earnings forecasts that analysts issue for firm announcement j in the 90 days before the announcement date t.[6] The median dispersion remains stable from the 1980s to 2015, but the distributions significantly widen during the financial crisis of 2008 and 2009. As some of my results show, the responsiveness of stock prices to earnings

[6] I calculate this measure for earnings announcements with at least four analyst forecasts.

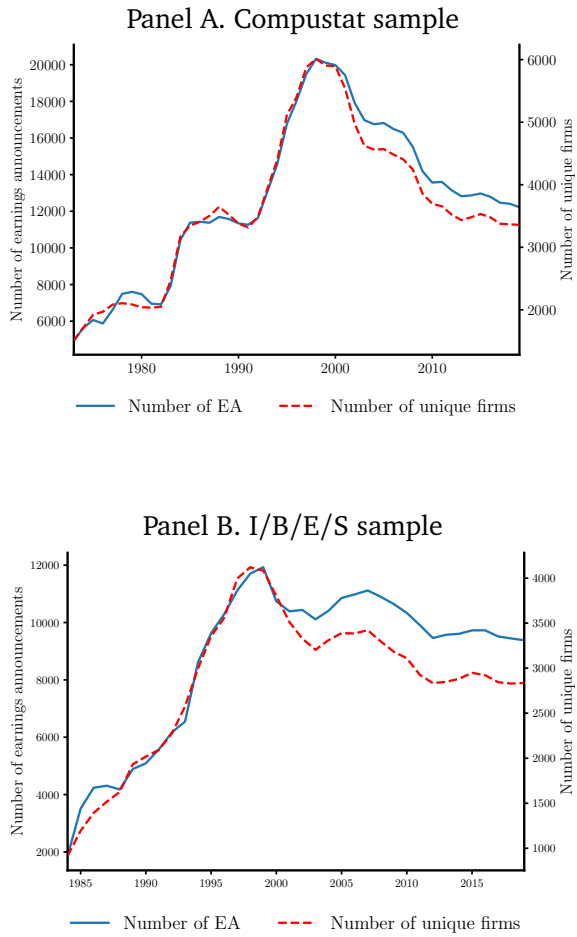

Figure 2: The number of firms and earnings announcements

Description: This figure shows the number of unique firms and the number of earnings announcements (EA) per year for the Compustat sample in Panel A and for the I/B/E/S sample in Panel B. The sample period is from January 1, 1973 to December 31, 2019 for the Compustat sample and from January 1, 1984 to December 31, 2019 for the I/B/E/S sample.

surprises weakens during the financial crisis, consistent with the theoretical implications of Cujean and Hasler (2017) where investor disagreement spikes in bad times, causing a sluggish price response to news.

The second earnings news measure is the random-walk earnings surprise. As in Livnat and Mendenhall (2006), random-walk earnings surprises are defined as

$$\text{Random-walk surprise}_{i,j,t} = \frac{EPS_{i,j,t} - EPS_{i,j-4}}{P_{i,j}}, \tag{3}$$

where $EPS_{i,j,t}$ is the earnings per share of firm i's quarterly earnings announcement j announced on day t, $EPS_{i,j-4}$ is the prior year same-quarter earnings announcement, and $P_{i,j}$ is the price per share at the end of quarter of announcement j from Compustat.[7] I further winsorize random-walk earnings surprises at the 1st and 99th percentiles

The literature shows price drifts are more persistent following earnings announcements when surprises are calculated using analyst forecasts (see Livnat and Mendenhall, 2006). Moreover, Walther (1997) finds sophisticated market participants put more weight on analyst forecasts than random walk forecasts. I will show that in the past 30 years, for stocks with both analyst earnings surprises and random-walk earnings surprises, their stock prices respond much more strongly to analyst earnings surprises.

An important implication of the two different earnings surprise measures is the number of stocks with missing analyst earnings surprises is large. Among the 593,654 stocks with random-walk earnings surprises (from the Compustat sample), 289,654 (49%) of those do not have analysts following. Panel A of Figure 4 shows the fraction of earnings announcements in Compustat with analyst earnings forecasts over time. Since 2005, approximately 70% of stocks in the Compustat sample have analysts following for which I can compute analyst earnings surprises. Panel B of Figure 4 shows among those with missing analyst earnings surprises, approximately 80% of these firms since the year 2000 are stocks with market capitalization below the NYSE 20th percentile, i.e., microcap stocks. Thus, it is essential to note the difference in stock composition among

[7] A number of papers scales the random-walk earnings surprises using the standard deviation in $EPS_{i,j,t} - EPS_{i,j-4}$ over the previous four or eight continuous quarters as opposed to using the stock price. Doing so eliminates stocks with less than one or two years of data.

Panel A: All-but-microcap stocks

	1984-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019
N. of EA	21,868	25,787	36,416	34,214	31,095	31,426	25,474
Mean	-0.37	-0.16	-0.04	0.04	-0.10	0.03	0.05
P25	-0.13	-0.07	0.00	0.00	-0.03	-0.03	-0.02
P50	0.00	0.00	0.02	0.03	0.05	0.04	0.05
P75	0.07	0.07	0.10	0.14	0.22	0.17	0.17
St. dev.	3.09	1.96	2.02	2.24	2.82	1.72	1.36

Panel B: Microcap stocks

	1984-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019
N. of EA	6,209	10,711	19,257	17,901	22,762	16,814	12,528
Mean	-1.37	-0.78	-0.54	-0.34	-0.95	-0.50	-0.43
P25	-0.89	-0.39	-0.19	-0.14	-0.45	-0.35	-0.44
P50	-0.06	0.00	0.02	0.04	0.02	0.06	0.05
P75	0.14	0.17	0.24	0.31	0.42	0.47	0.51
St. dev.	5.86	4.42	4.42	4.64	6.22	5.44	5.18

Table 2: Descriptive statistics: Analyst earnings surprises

Description: This table reports summary statistics for earnings surprises defined in Equation (1) for different periods for all-but-microcap and microcap stocks. Microcap stocks have market capitalization below the NYSE 20th percentile. N. EA corresponds to the number of earnings announcements. P25, P50, P75, and St. dev. correspond to the 25th, 50th, and 75th percentiles, and the standard deviation, respectively, of earnings surprises (in percent). The sample consists of U.S.-based firms with at least one earnings forecast in I/B/E/S with accounting data in Compustat, specifically, total assets and market capitalization, at the end of December of the previous calendar year. The sample period is from January 1, 1984 to December 31, 2019.

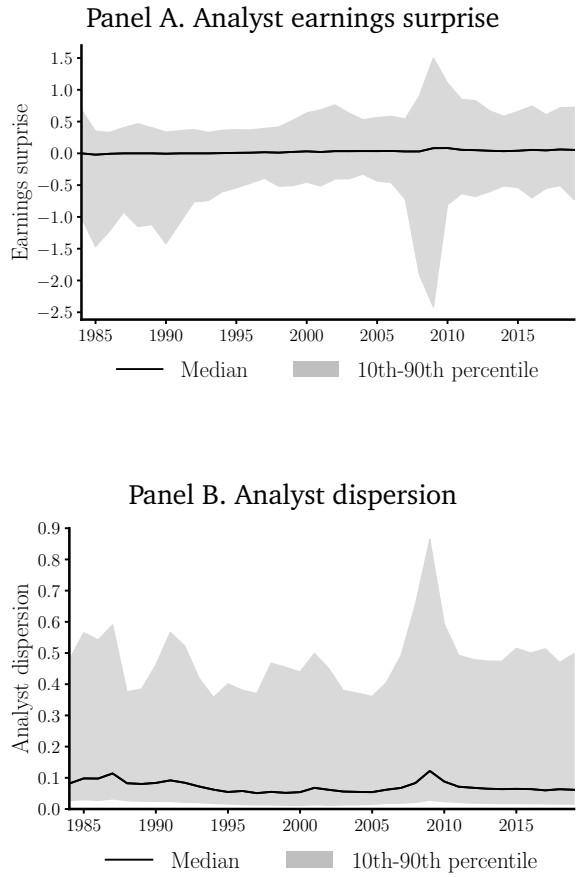

Figure 3: Analyst earnings surprise and forecast dispersion

Description: This figure shows the median (solid black line) and the 10th-90th percentile range (shaded area) for analyst earnings surprises defined in Equation (1) in Panel A and for analyst forecast dispersions defined in Equation (2) in Panel B. The sample consists of U.S.-based firms with at least one earnings forecast in I/B/E/S with accounting data in Compustat, specifically, total assets and market capitalization, at the end of December of the previous calendar year. The analyst forecast dispersion is calculated for earnings announcements with at least four analyst forecasts. The sample period is from January 1, 1984 to December 31, 2019.

Interpretation: The distribution of earnings surprises and analyst dispersion remain generally constant over time, except during the financial crisis (2007-2008).

earnings announcements when comparing analyst earnings surprises and random-walk earnings surprises in price formation studies. Among the 80 papers reported in Table A.1 that examine the relation between earnings surprises and returns following earnings announcements, 33, 30, and 17 papers compute earnings surprises using analyst forecasts, random-walk, or both, respectively.

3 The Evolution of Price Efficiency Following Earnings Announcements

I conduct the empirical analysis as follows. I first present visual evidence of price formation at the daily horizon around earnings announcements, followed by a regression analysis examining analyst earnings surprises' statistical power at predicting future returns. I then repeat the analysis using random-walk earnings surprises and highlight some of the caveats associated with this measure.

3.1 Analyst earnings surprises

3.1.1 A visual representation of price formation to analyst earnings surprises

A first test of the evolution of market price efficiency over time is to examine changes in price formation dynamics around earnings announcements. I follow Hirshleifer *et al.* (2009) and calculate abnormal daily returns to account for the return premium associated with size and book-to-market. I deduct from stock returns the return on the size and book-to-market benchmark portfolios obtained from Ken French's data library.[8] Stocks are matched to one of 25 portfolios at the end of June of every year based on their market capitalization and book-to-market ratio.[9] I define the buy-and-hold abnormal returns for firm i's earnings announcement j from day τ to T ($\tau < T$) as

$$BHAR[\tau, T]_{i,j} = \prod_{k=\tau}^{T}(1 + R_{i,j,k}) - \prod_{k=\tau}^{T}(1 + R_{p,k}), \tag{4}$$

[8]Kenneth French's data library is found at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

[9]Market capitalization is taken at the end of June of every year. The book-to-market ratio is calculated as the book equity of the last fiscal year-end in the prior calendar year divided by the market value of equity at the end of December of the previous year.

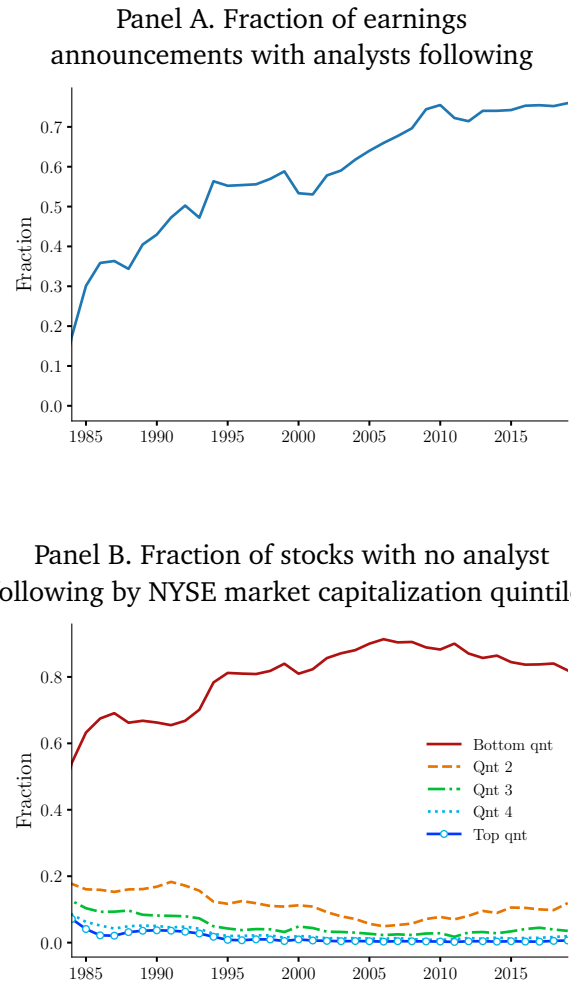

Figure 4: Earnings announcements with analyst earnings surprises

Description: Panel A of this figure shows the fraction of earnings announcements from the Compustat sample that have analyst following in I/B/E/S (i.e., stocks for which we can calculate an analyst earnings surprise defined in Equation (1)). Panel B shows the fraction of stocks with no analyst following in I/B/E/S by NYSE market capitalization quintiles. The sample period is from January 1, 1984 to December 31, 2019.

Interpretation: The majority of stocks with missing analyst earnings surprises are stocks with market capitalization below the NYSE 20th percentile (microcap stocks).

where $R_{i,j,k}$ is the daily stock return of the firm and $R_{p,k}$ is the return on the size and book-to-market matching Fama-French portfolio on day k.

Figure 5 graphically depicts the average BHAR one trading day before the earnings announcement (τ =−1) to 60 trading days following the announcement (T=60) for each earnings surprise quintile for different periods since 1984 for the I/B/E/S sample firms.[10] The shaded area corresponds to the pointwise 95% confidence intervals around the BHAR. Because I do not know the precise timestamp of the earnings announcement release (before 1996), day 0 corresponds to the earnings announcement date and the following trading day. I must combine both trading days because an announcement of firm earnings after 4 p.m. is only impounded in the stock price (at the daily frequency) on the following trading day.[11]

Figure 5 highlights the evolution of price drifts since 1984 and shows a clear demarcation in price drifts across earnings surprise quintiles following earnings announcements. The period of 1984 to 1990 shows slow and continuous price drifts following earnings announcements. From 1991 to 2010, however, price drifts gradually become less persistent over time. In the latter part of the sample, from 2006 to 2010, price drifts are only present for the top earnings surprise quintile.[12] From 2011, however, there are no pronounced price drifts following earnings announcements; price discovery mainly occurs at the time of announcements.[13]

A decrease in post-announcement drifts might indicate prices before announcements better reflect the news due to more widespread information leakage or, as shown in Hendershott *et al.* (2015), due to sophisticated institutional traders trading on their private information before the actual news release. Figure 6 presents the BHAR -60 to -1 days before earnings announcements. Pre-announcement drifts have considerably weakened

[10] Sixty trading days following an earnings announcement most likely overlap with the following earnings announcement. I chose 60 trading days because this time window is commonly used in accounting and finance literature to analyze drifts.

[11] Berkman and Truong (2009) demonstrate the importance of accounting for after-hours announcements for event studies around earnings announcements.

[12] Top earnings surprise quintiles show more pronounced drifts than bottom earnings surprise quintiles, consistent with the findings of Doyle *et al.* (2006)

[13] I report in Table IA.2 and IA.3 of the Internet Appendix the results from regressing pre-announcement drifts at various horizon (BHAR[-60, -1], [-30, -1], and [-15, -1]) on analyst and random-walk earnings surprises, respectively. The reported results confirm a significant decline in pre-announcement BHAR over time, but the relation between pre-announcement BHAR and surprises remains positive and statistically significant.

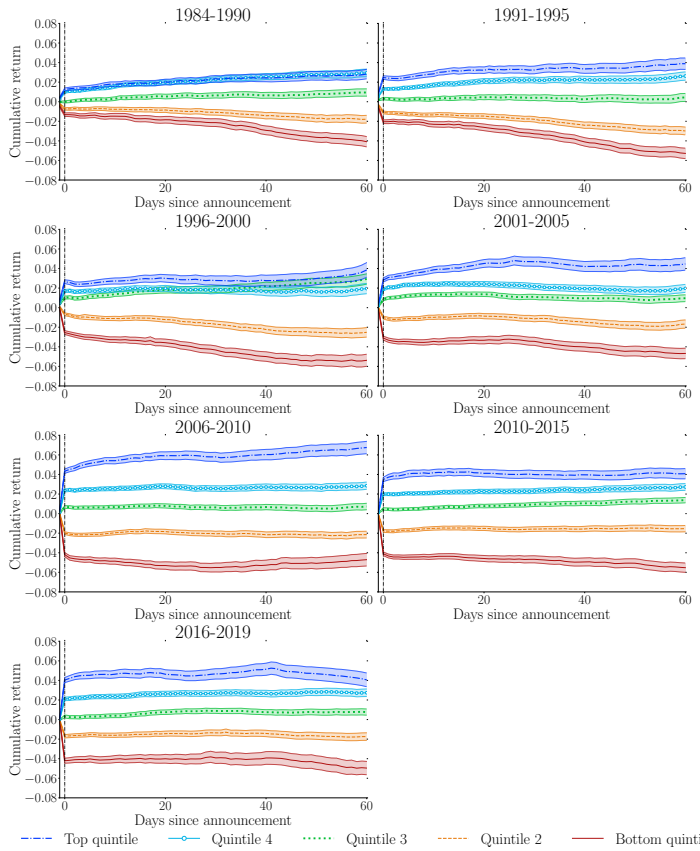

Figure 5: Post-earnings announcement drift: Analyst earnings surprises

Description: This figure shows the average in buy-and-hold abnormal returns (BHAR) following earnings announcements for each analyst earnings surprise quintile sort for different time periods. I define BHAR for firm earnings announcement j from day τ to T ($\tau < T$) as

$$BHAR[\tau, T]_{i,j} = \prod_{k=\tau}^{T}(1 + R_{i,j,k}) - \prod_{k=\tau}^{T}(1 + R_{p,k}),$$

where $R_{i,j,k}$ is the return of the stock i's earnings announcement j and $R_{p,k}$ is the return on the size and book-to-market matching Fama-French portfolio on day k. This figure represents the BHAR from one day before the announcement ($\tau = -1$) to day T, where T varies from $T = 0$ to $T = 60$ trading days. Day $T = 0$ is the BHAR of the earnings announcement date reported in I/B/E/S and the following trading day. I combine both trading days because I do not have the exact earnings announcement timestamp. The shaded area represents the pointwise 95% confidence bands around the average BHAR. The vertical line corresponds to the earnings announcement day ($T = 0$). The sample period is from January 1, 1984 to December 31, 2019.

Interpretation: The persistence in post-earnings announcement drifts conditioned on analyst earnings surprises has significantly weakened over time.

over time. A potential factor contributing to pre-announcement drifts' disappearance is the Regulation Fair Disclosure (Reg FD) enacted in 2000. This regulation directs firms to release all information pertinent to an earnings result on the scheduled earnings announcement day and aims to reduce information leakage to ensure all investors have access to the same information at the same time (Bailey *et al.*, 2003; Michaely *et al.*, 2014). Heflin *et al.* (2003) find absolute cumulative abnormal returns before earnings announcements are smaller for the three-quarters post-FD than the three quarters pre-FD.[14]

Overall, these results paint a clear picture of the near disappearance of the post-earnings announcement drift anomaly. They further suggest prices have become more efficient at incorporating earnings surprises at the time of the announcement.

3.1.2 Analyst earnings surprises: A regression analysis

I perform a secondary analysis to examine whether price drifts are becoming less persistent over time is due to stock prices becoming more efficient at incorporating earnings surprises on announcement date. I further examine the statistical power of analyst earnings surprises at predicting post-announcement returns. To examine these issues, I report in Table 3 the coefficient estimates for all-but-microcap and microcap stocks of the following regression models:

$$BHAR[0,1]_{i,j} = \beta Surprise\ rank_{i,j} + \alpha_i + \alpha_q + \varepsilon_{i,j} \text{ in Panel A and} \quad (5)$$

$$BHAR[2,60]_{i,j} = \beta Surprise\ rank_{i,j} + \alpha_i + \alpha_q + \varepsilon_{i,j} \text{ in Panel B.}$$

$BHAR[0,1]_{i,j}$ and $BHAR[2,60]_{i,j}$ corresponds to firm i's announcement date and post-announcement buy-and-hold abnormal returns for announcement j. $Surprise\ rank_{i,j}$ is a decile rank of the analyst earnings surprises defined in Equation (1). I examine the impact of earnings surprises in decile ranks because the distribution of earnings surprises has high kurtosis relative to a normal- or t-distribution (see DellaVigna and Pollet, 2009). The decile ranks are formed on each year-quarter using the previous quarter observations to define the quantiles breakpoints to avoid look-ahead

[14] Eleswarapu *et al.* (2004) show that the information asymmetry two days before earnings announcements declined after the passage of Regulation FD.

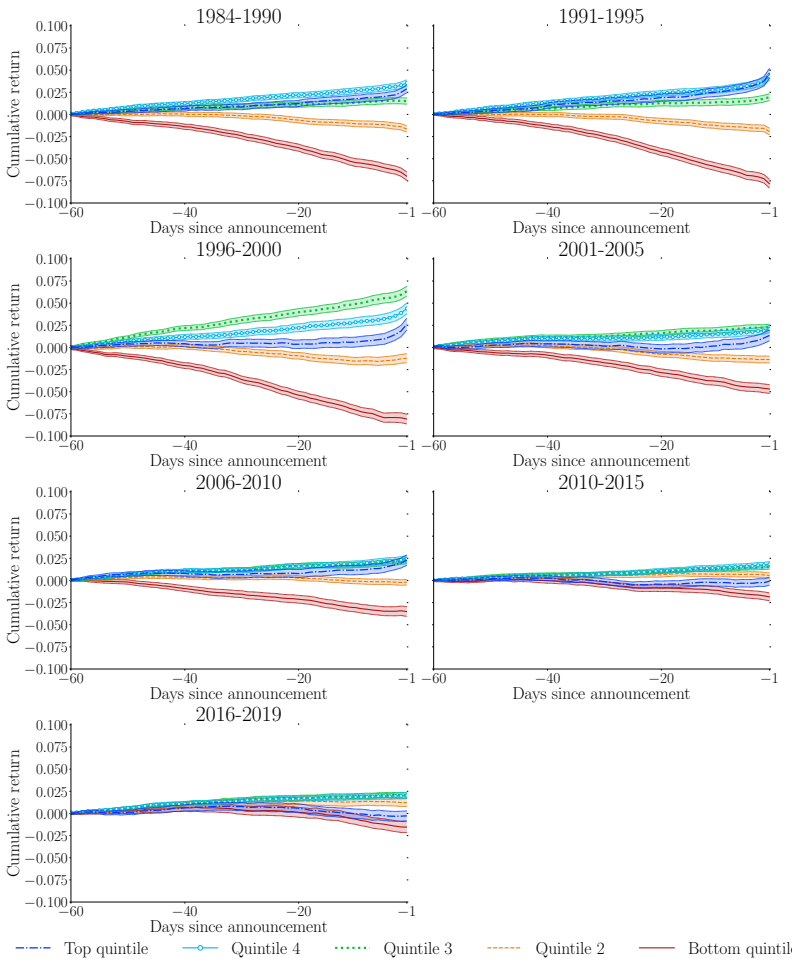

Figure 6: Pre-earnings announcement drift: Analyst earnings surprises

Description: This figure shows the average in buy-and-hold abnormal returns (BHAR) before earnings announcements for each analyst earnings surprise quintile sort for different time periods. I define BHAR for firm earnings announcement j from day τ to T ($\tau < T$) as

$$BHAR[\tau, T]_{i,j} = \prod_{k=\tau}^{T}(1 + R_{i,j,k}) - \prod_{k=\tau}^{T}(1 + R_{p,k}),$$

where $R_{i,j,k}$ is the return of the stock i's earnings announcement j and $R_{p,k}$ is the return on the size and book-to-market matching Fama-French portfolio on day k. This figure represents the BHAR from 60 days before the announcement ($\tau = -60$) to day T, where T varies from $T = -59$ to $T = -1$ trading days. Earnings announcements occur on day 0. The shaded area represents the pointwise 95% confidence bands around the average BHAR. The sample period is from January 1, 1984 to December 31, 2019.

Interpretation: The persistence in pre-earnings announcement drifts conditioned on analyst earnings surprises has significantly weakened over time.

bias. α_i and α_q correspond to firm and year-quarter fixed effects.[15]

Table 3 Panel A reports the impact of earnings surprises on BHAR[0,1] for all-but-microcap (microcap) stocks increases over time, from 20 (30) bps in the early part of the sample to 120 (100) bps in the latter part of the sample. Also, this increase in magnitude is associated with an increase in R^2, from 1.7 to 11.7% for all-but-microcap stocks and from 2.4 to 9.2% for microcap stocks. Panel A further shows the largest increase in price informativeness to earnings news (R^2) on the announcement date occurs after 2005. In untabulated results, I find such a substantial increase in the estimates of $Surprise\ rank$ and the R^2 is not due to the inclusion of firm and time fixed effects, and thus the increase in R^2 is mainly attributed to prices becoming more informative with respect to earnings surprises. Another key result is since 2006, the magnitude associated with the earnings surprise has remained relatively stable for both sets of stocks.

Results presented in Panel B of Table 3 show that for the full sample (column (1)), the power of $Surprise\ rank$ to predict post-announcement price drifts (BHAR[2,60]) is positive and statistically significant at the 1% level for both sets of stocks. However, the predictability declines over time, consistent with the weakening in PEAD shown in Figure 5. Moreover, Panel B shows after 2005, for all-but-microcap stocks, the relation between earnings surprises and price drifts (BHAR[2,60]) is not statistically significant. Only in recent years (2016-2019) do analyst earnings surprise fail to predict at conventional statistical level stock returns post-announcement for microcap stocks. These results show the importance of examining the evolution of price efficiency over time. Aggregating long-time series might highlight the presence of PEAD (as shown in column (1)) but buries evidence in the weakening of such phenomenon over time.

I further report in the Internet Appendix, Table IA.4, the results of the empirical test defined in equation (5) but including the pre-announcement returns (BHAR[-60,-1]) as a control variable. The weakening in pre-earnings announcement drifts might explain why stock returns are more responsive to earnings surprises on announcement dates and the disappearance of post-announcement drifts. I find the loadings on BHAR[-60,1] is negative and statistically significant at the 5% and 1% level, but does not alter in any significant way the loadings on the earnings surprise rank reported in

[15] I report in Panel A of Table IA.1 in the Internet Appendix the results using BHAR[2,15] as dependent variable.

Panel A. Dependent variable: $BHAR[0,1]$

All-but-microcap stocks

	Full sample	1984-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Surprise rank	0.007***	0.002***	0.003***	0.006***	0.008***	0.012***	0.011***	0.012***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
N	206,280	21,868	25,787	36,416	34,214	31,095	31,426	25,474
R^2	0.064	0.017	0.028	0.032	0.060	0.115	0.117	0.117

Microcap stocks

	Full sample	1984-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Surprise rank	0.008***	0.003***	0.005***	0.006***	0.007***	0.010***	0.009***	0.010***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	106,182	6,209	10,711	19,257	17,901	22,762	16,814	12,528
R^2	0.072	0.024	0.042	0.045	0.062	0.102	0.098	0.092

Panel B. Dependent variable: $BHAR[2,60]$

All-but-microcap stocks

	Full sample	1984-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Surprise rank	0.002***	0.003***	0.003***	0.001	0.002**	-0.001	0.000	-0.002**
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
N	206,321	21,870	25,793	36,430	34,217	31,108	31,424	25,479
R^2	0.000	0.004	0.002	0.000	0.000	0.000	0.000	0.001

Microcap stocks

	Full sample	1984-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2019
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Surprise rank	0.004***	0.003***	0.003***	0.004***	0.004***	0.003***	0.003***	0.002
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
N	106,217	6,211	10,713	19,260	17,913	22,773	16,815	12,532
R^2	0.002	0.002	0.002	0.001	0.002	0.001	0.002	0.000

Table 3: Price formation to analyst earnings surprises

Description: This table reports coefficient estimates of the following regression models:

$$BHAR[0,1]_{i,j} = \beta Surprise\ rank_{i,j} + \alpha_i + \alpha_q + \varepsilon_{i,j} \text{ in Panel A and}$$

$$BHAR[2,60]_{i,j} = \beta Surprise\ rank_{i,j} + \alpha_i + \alpha_q + \varepsilon_{i,j} \text{ in Panel B,}$$

where $BHAR[0,1]$ and $BHAR[2,60]$ are the stock i's announcement j buy-and-hold abnormal returns (BHAR) on announcement date and post-announcement, respectively. $Surprise\ rank$ is the decile rank of analyst earnings surprises defined in Equation (1). α_i and α_q correspond to firm and year-quarter fixed effects. The decile ranks are formed on each year-quarter using the previous quarter observations to define the decile cutoffs. See the caption of Figure 5 for the definition of BHAR. The results are reported for all-but-microcap and microcap stocks. Microcap stocks are those with market capitalization smaller than the NYSE 20th percentile. Standard errors are clustered by firm and earnings announcement date in Panel A and by firm and announcement year-quarter in Panel B. ***, ** and * indicate a two-tailed test significance level of less than 1, 5, and 10%, respectively. The sample period is from January 1, 1984 to December 31, 2019.

Interpretation: Panel A shows that stocks returns (BHAR[0,1]) on announcement dates are more responsive to analyst earnings surprises over time. Panel B shows that in recent years, analyst earnings surprises fail to predict post-earnings announcement returns (BHAR[2,60]).

Table 3.

I next document how the improvement in price efficiency following earnings announcements has changed over time by NYSE size quintile breakpoints and whether PEAD remain present but at a shorter horizon. For each NYSE size quintile breakpoint, I estimate Equation (5) where this time the dependent variable corresponds to buy-and-hold abnormal returns over different daily intervals following announcements, specifically, BHAR[0,1], BHAR[2,5], BHAR[6,10], BHAR[11,30], and BHAR[31,60]. I graphically depict in Figure 7 the estimated stock return responses to analyst earnings surprises (β coefficient) for the full-sample and over different periods by NYSE size quintile breakpoints. The 95% confidence intervals are represented by error bars. The figure shows from 1996 to 2005, stock return responses to earnings surprises following announcements have generally been positive and statistically significant and concentrated in the first ten days across all size quintiles. From 2006, the PEAD horizon has shortened in size quintiles, i.e., the improvement in price efficiency (a decline in β) following announcements occurred first for larger firms. Since 2011, the only suggestive evidence of PEAD is for microcap stocks over the 2 to 5-day horizon following announcements where the estimated β coefficients are approximately equal to 0.001 and statistically significant at the 95% level. For the remaining daily intervals, the coefficients are not statistically significant. I conclude in recent years there is no evidence of prolonged persistence price drifts following earnings announcements across all NYSE size quintiles.

3.2 Random-walk earnings surprises

3.2.1 A visual representation of price formation to random-walk earnings news

In this section, I examine price formation to random-walk earnings surprises. As previously shown in Section 2, analysis involving random-walk earnings surprises almost doubles the sample number of earnings announcements, and the increase is mostly comprised of microcap stocks. As microcap stocks are usually associated with the presence of anomalies in asset pricing (Hou *et al.*, 2020) and random-walk earnings surprises remain a popular measure of earnings surprises (as reported in Table A.1), it is of interest to examine whether such surprise remains associated with post-earnings announcement drifts.

Figure 8 highlights the evolution of price drifts conditioned on random-

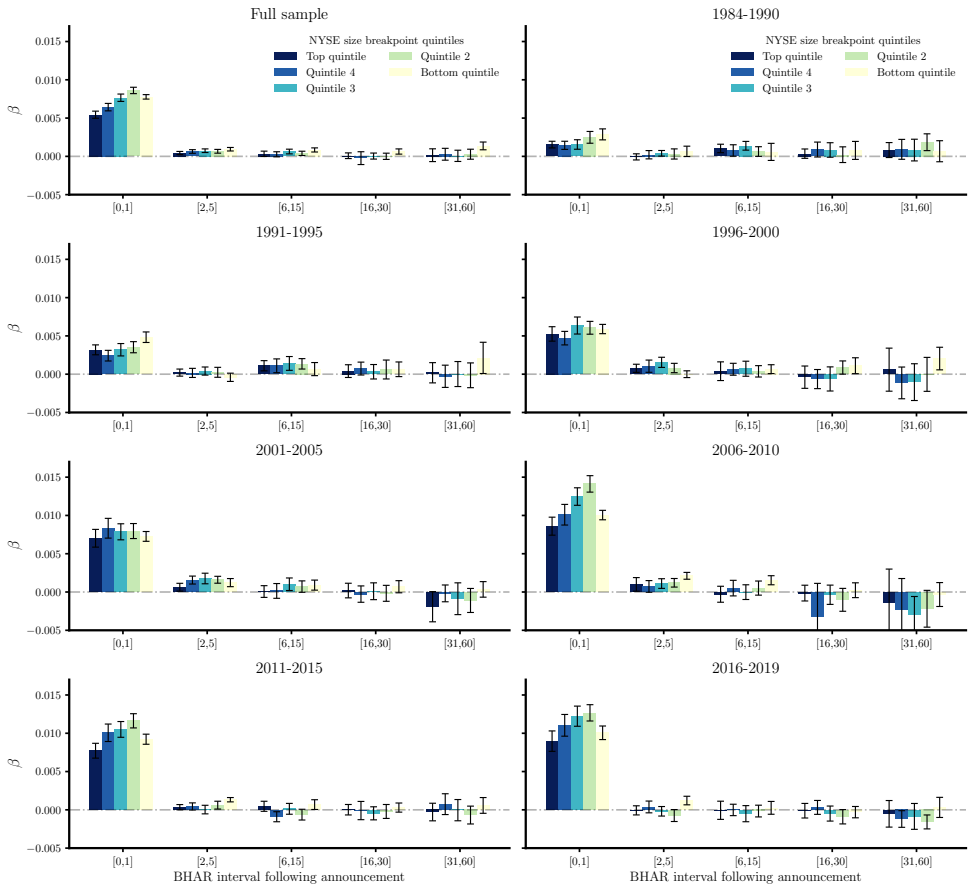

Figure 7: The impact of analyst surprises on stock returns over different daily intervals

Description: This figure shows the estimated response coefficient (β) of the response of stock returns to analyst earnings surprises estimated from the following regression:

$$BHAR[\tau, T]_{i,j} = \beta Surprise\ rank_{i,j} + \alpha_i + \alpha_q + \varepsilon_{i,j}$$

where BHAR corresponds to the stock i's announcement j buy-and-hold abnormal returns (BHAR) from day τ to T. See the caption of Figure 5 for the definition of BHAR. $Surprise\ rank$ is the decile rank of analyst earnings surprises defined in Equation (1). The decile ranks are formed on each year-quarter using the previous quarter observations to define the decile cutoffs. α_i and α_q correspond to firm and year-quarter fixed effects. The x-axis corresponds to the daily interval $[\tau, T]$ following earnings announcements. The results are reported for over the full sample and for different periods by NYSE size quintile breakpoints. Standard errors are clustered by firm and earnings announcement date for $[\tau = 0, T = 1]$ and by firm and announcement year-quarter for the other daily intervals. The 95% confidence interval are represented by the black error bars. The sample period is from January 1, 1984 to December 31, 2019.

Interpretation: In recent years, PEAD conditioned on analyst earnings surprises does not hide in more subtle ways. PEAD is not present for the smallest all-but-microcap stocks (top four quintiles) and at shorter horizon. The PEAD horizon for microcap stock (bottom quintile) is no more than five days.

walk earnings surprise quintiles since 1973 and three main insights standout from this figure. First, as in Figure 5, there is a demarcation in price drifts across the random-walk earnings surprise quintiles following earnings announcements. However, the price drifts are at times more "noisy." For example, in several periods, e.g., 1981-1985, 1986-1990, and more recently, 2016-2019, the demarcation between the top two quintiles overlaps. Second, the initial response of stock returns to surprises ($t = 0$), is on average weaker than the response to analyst earnings surprises shown in Figure 5. Finally, post-earnings announcement drifts have weakened over time, and in recent years (2016-2019), such drifts show little to no persistence.

3.2.2 Random-walk earnings surprises: A Regression analysis

I next reestimate the regression specified in Equation (5) with the modification $Surprise\ rank$ consist of a decile rank of the random-walk earnings surprises defined in Equation (3).[16] The results are reported in Table 4 and confirms the insights of Figure 8. When comparing the results reported in Panel A of Table 4 to those in Panel A of Table 3, for both all-but-microcap and microcap stocks, the overall responsiveness of announcement day returns (BHAR[0,1]) to random-walk earnings surprises is approximately two to three times smaller than to the responsiveness to analyst earnings surprises. For example, from 2016 to 2019, the estimated coefficient is 0.004 (0.006) for all-but-microcap (microcap) stocks, which is 3 (2) times smaller than the estimated response to analyst earnings surprises. The explanatory power (R^2) of the regressions are also much smaller than those reported with analyst earnings surprises. Over the various period, the R^2 is at most 1.8% and 3.6% for all-but-microcap and microcap stocks, respectively. This contrasts sharply to the large R^2 obtained for analyst earnings surprises (Table 3), which have increased over time to 11.7% for all-but-microcap stocks and 9.2% for microcap stocks.

I note comparing the coefficients of Table 3 and Table 4 can be misleading as the number of stocks in both analyses are different because several stock-observations in Table 4 do not have analyst coverage. I reestimate the regression with random-walk earnings surprises as an explanatory variable for stocks with analyst coverage and report the results in

[16] I report in Panel B of Table IA.1 in the Internet Appendix the results using BHAR[2,15] as dependent variable.

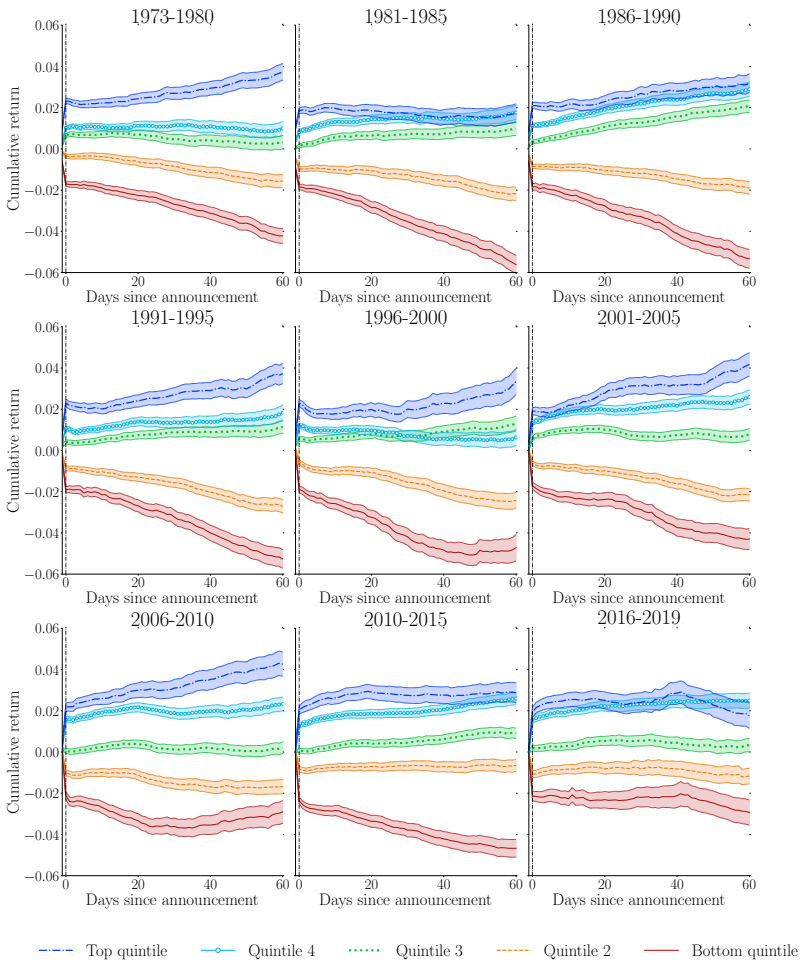

Figure 8: Post-earnings announcement drift: Random-walk surprises

Description: This figure shows the average in buy-and-hold abnormal returns (BHAR) before earnings announcements for each random-walk earnings surprise quintile sort for different time periods. I define BHAR for firm earnings announcement j from day τ to T ($\tau < T$) as

$$BHAR[\tau, T]_{i,j} = \prod_{k=\tau}^{T}(1 + R_{i,j,k}) - \prod_{k=\tau}^{T}(1 + R_{p,k}),$$

where $R_{i,j,k}$ is the return of the stock i's earnings announcement j and $R_{p,k}$ is the return on the size and book-to-market matching Fama-French portfolio on day k. This figure represents the BHAR from one day before the announcement ($\tau = -1$) to day T, where T varies from $T = 0$ to $T = 60$ trading days. Day $T = 0$ is the BHAR of the earnings announcement date reported in Compustat and the following trading day. I combine both trading days because I do not have the exact earnings announcement timestamp. The shaded area represents the pointwise 95% confidence bands around the average BHAR. The vertical line corresponds to the earnings announcement day ($T = 0$). The sample period is from January 1, 1973 to December 31, 2019.

Interpretation: The persistence in post-earnings announcement drifts conditioned on random-walk earnings surprises has significantly weakened over time.

Panel A. Dependent variable: $BHAR[0,1]$

All-but-microcap stocks

	Full sample (1)	1973-1990 (2)	1991-1995 (3)	1996-2000 (4)	2001-2005 (5)	2006-2010 (6)	2011-2015 (7)	2016-2019 (8)
Surprise rank	0.003***	0.002***	0.002***	0.002***	0.002***	0.004***	0.004***	0.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	296,462	87,047	33,372	43,664	38,818	32,980	33,413	27,168
R^2	0.011	0.018	0.008	0.004	0.004	0.011	0.018	0.016

Microcap stocks

	Full sample (1)	1973-1990 (2)	1991-1995 (3)	1996-2000 (4)	2001-2005 (5)	2006-2010 (6)	2011-2015 (7)	2016-2019 (8)
Surprise rank	0.005***	0.003***	0.005***	0.005***	0.005***	0.006***	0.006***	0.006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	297,192	64,176	33,801	53,823	48,328	42,601	31,893	22,570
R^2	0.030	0.030	0.031	0.026	0.029	0.030	0.036	0.029

Panel B. Dependent variable: $BHAR[2,60]$

All-but-microcap stocks

	Full sample (1)	1973-1990 (2)	1991-1995 (3)	1996-2000 (4)	2001-2005 (5)	2006-2010 (6)	2011-2015 (7)	2016-2019 (8)
Surprise rank	0.001**	0.003***	0.001*	-0.002	-0.000	-0.003	-0.000	-0.003*
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)	(0.002)
N	296,560	87,084	33,383	43,688	38,827	32,996	33,410	27,172
R^2	0.000	0.003	0.000	0.000	0.000	0.001	0.000	0.002

Microcap stocks

	Full sample (1)	1973-1990 (2)	1991-1995 (3)	1996-2000 (4)	2001-2005 (5)	2006-2010 (6)	2011-2015 (7)	2016-2019 (8)
Surprise rank	0.005***	0.005***	0.004***	0.004***	0.005***	0.003***	0.004***	0.003***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
N	297,428	64,249	33,825	53,853	48,395	42,636	31,892	22,578
R^2	0.003	0.005	0.002	0.001	0.003	0.001	0.004	0.001

Table 4: Price formation to random-walk earnings surprises

Description: This table reports coefficient estimates of the following regression models:

$$BHAR[0,1]_{i,j} = \beta Surprise\ rank_{i,j} + \alpha_i + \alpha_q + \varepsilon_{i,j} \text{ in Panel A and}$$

$$BHAR[2,60]_{i,j} = \beta Surprise\ rank_{i,j} + \alpha_i + \alpha_q + \varepsilon_{i,j} \text{ in Panel B,}$$

where $BHAR[0,1]$ and $BHAR[2,60]$ are the stock is announcement j buy-and-hold abnormal returns (BHAR) on announcement date and post-announcement, respectively. *Surprise rank* is the decile rank of random-walk earnings surprises defined in Equation (3). α_i and α_q correspond to firm and year-quarter fixed effects. The decile ranks are formed on each year-quarter using the previous quarter observations to define the decile cutoffs. See the caption of Figure 5 for the definition of BHAR. The results are reported for all-but-microcap and microcap stocks. Microcap stocks are those with market capitalization smaller than the NYSE 20th percentile. Standard errors are clustered by firm and earnings announcement date in Panel A and by firm and announcement year-quarter in Panel B. ***, ** and * indicate a two-tailed test significance level of less than 1, 5, and 10%, respectively. The sample period is from January 1, 1973 to December 31, 2019.

Interpretation: Panel A shows that stocks returns (BHAR[0,1]) on announcement dates are more responsive to random-walk earnings surprises over time. Panel B shows that since 1996, random-walk earnings surprises fail to predict post-earnings announcement returns (BHAR[2,60]) for all-but-microcap stocks. Random-walk earnings surprises still predict post-earnings announcement returns (BHAR[2,60]) for microcap stocks.

Table IA.6 of the Internet Appendix. The table reports similar magnitudes for the estimated coefficients as those reported in Table 4.

Returning to Table 4, Panel B reports for all-but-microcap stocks, random-walk earning surprises fail to positively predict at conventional statistical level (i.e., t-statistic > 1.96) post-announcement stock returns (BHAR[2,60]) after 1990. However, for microcap stocks, the relation is positive and statistically significant at the 1% level across the different time intervals. If we include only stocks with analysts following, results reported in Panel B of Table IA.6 of the Internet Appendix show for microcap stocks, the relation between random-walk earnings surprises and post-announcement returns to be positive and statistically significant at the 1% level for the full-sample (column (1)). Since 1996, however, the positive relation between random-walk surprises and post-announcement returns is much more sporadic and weak. In recent years, random-walk surprises fail to predict post-announcement returns for microcap stocks with analyst coverage.

Panel B of Table 4 presents evidence of PEAD for microcap stocks. I next investigate whether such drift is indeed persistent over a 60-day horizon. To do so, I estimate Equation (5) where the dependent variable corresponds to buy-and-hold abnormal returns over different daily intervals following earnings announcements. Figure 9 shows the estimated stock return response to random-walk earnings surprises (β coefficient) for the full-sample and over different periods by NYSE size quintile breakpoints. Since 1991, the figure shows for large stocks (top four size quintiles), evidence of PEAD over the different daily intervals following announcements is generally absent as the estimated β are not statistically significant at the 95% confidence level. Consistent with the results in Panel B of Table 4, the only remaining evidence of PEAD in recent years is found for microcap stocks (bottom NYSE size quintile). Prior to 2016, random-walk surprises for these stocks did indeed impact returns over a 60-day horizon. Since 2016, however, PEAD is concentrated over just a few days after announcements – that is, the 2 to 5-day horizon β is positive and statistically significant at the 95% confidence level but not significant for the remaining horizons.

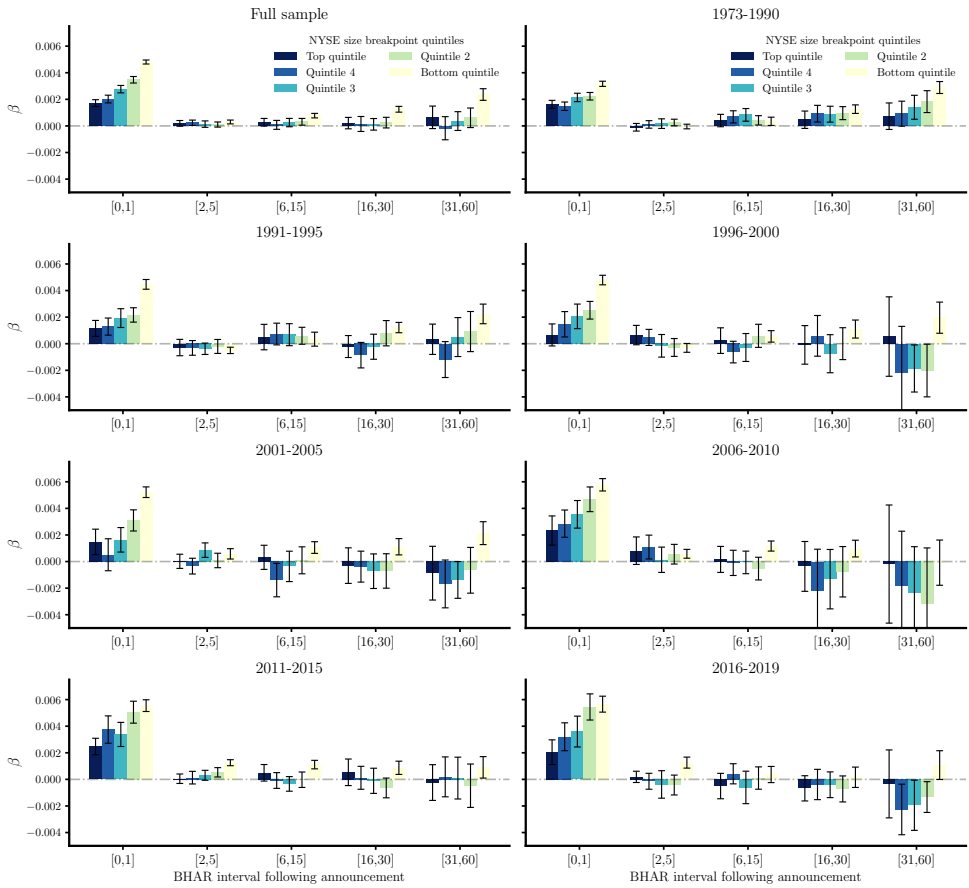

Figure 9: The impact of random-walk surprises on stock returns over different daily intervals

Description: This figure shows the estimated response coefficient (β) of the response of stock returns to earnings surprises estimated from the following regression:

$$BHAR[\tau, T]_{i,j} = \beta Surprise\ rank_{i,j} + \alpha_i + \alpha_q + \varepsilon_{i,j}$$

where BHAR corresponds to the stock i's announcement j buy-and-hold abnormal returns (BHAR) from day τ to T. See the caption of Figure 5 for the definition of BHAR. $Surprise\ rank$ is the decile rank of random-walk earnings surprises defined in Equation (3). The decile ranks are formed on each year-quarter using the previous quarter observations to define the decile cutoffs. α_i and α_q correspond to firm and year-quarter fixed effects. The x-axis corresponds to the daily interval $[\tau, T]$ following earnings announcements. The results are reported for over the full sample and for different periods by NYSE size quintile breakpoints. Standard errors are clustered by firm and earnings announcement date for $[\tau = 0, T = 1]$ and by firm and announcement year-quarter for the other daily intervals. The 95% confidence interval are represented by the black error bars. The sample period is from January 1, 1973 to December 31, 2019.

Interpretation: Since 1996, there is no evidence of PEAD conditioned on random-walk surprises for the top four size quintiles. In recent years, the PEAD horizon for microcap stock (bottom quintile) is no more than five days.

4 Implications for Future Studies on Price Formation

The findings reported until now show stock prices incorporate analyst earnings surprises more quickly at the time of the announcement, earnings surprises have become weaker predictors of long-horizon stock returns following announcements over time, and, in recent years, earnings surprises fail to predict post-announcement returns. These results provide strong evidence of an improvement in stock prices' informational efficiency on the earnings announcement date. These findings suggest the following recommendations for future studies examining price formation around earnings announcements:

1. The dynamics of market efficiency over time implies that studies about price efficiency should be conducted separately over different periods. I show aggregating long time-series can highlight the presence of market inefficiencies when, in recent years, such inefficiencies have vanished.
2. Researchers should examine price efficiency to earnings news using analyst earnings surprises and not random-walk earnings surprises. Random-walk earnings surprises is a much noisier measure of earnings news relative to analyst earnings surprises to explain price reactions to earnings news. Also, the use of random-walk earnings surprises significantly increases the earnings announcement sample, but such an increase is primarily comprised of microcap stocks that do not have analyst coverage. I show random-walk earnings surprises can still predict post-announcement returns. However, this result is contributed mainly by microcap stocks with poor information environment (e.g., no analyst following), and such drift in recent years is concentrated just over a few days following announcements. Hou *et al.* (2020) show market anomalies are largely driven by microcap stocks and recommends researchers to minimize their impact in cross-sectional studies.
3. Price discovery of earnings surprises is generally complete at the time of announcement. Thus, future studies examining the relation between trading frictions (e.g., investor attention, liquidity) and price discovery are encouraged to use intraday data and examine price discovery at the time of the announcement. Such studies will provide more meaningful implications to today's financial markets

where high-frequency traders mostly govern price discovery (Hendershott and Riordan, 2013; Brogaard *et al.*, 2019; Grégoire and Martineau, 2021).

5 Do prices on announcement dates better reflect future prices?

Does the last recommendation from the previous section entail studies examining price formation at the daily horizon are now obsolete? Earning surprises consist of a noisy proxy of the "hard" information content embedded in earnings announcements. On announcement dates, other news elements such as "soft" information contained in earnings announcements (e.g., management conference calls) can take more time for market participants to assess its implication to firm valuation and to incorporate into stock prices. I previously documented that earnings surprises explain at most only 12% of the total price variation on announcement dates.

To generalize the information content of the earnings news and how such information makes its way into prices over time, I follow Biais *et al.* (1999) and Barclay and Hendershott (2003) and examine the slope of an unbiasedness regression. Such regression consists of regressing price changes from the announcement date to 60-day into the future (one-trading quarter) onto the announcement date price change, where the future price is assumed to be the "efficient" price. The results from these regressions will provide insights as to whether there remains some content of the earnings news that slowly incorporate stock prices following earnings announcements.

For this analysis, I rely on the I/B/E/S sample stocks (i.e., stocks with analyst coverage) and report the Compustat sample results in the Internet Appendix. Specifically, I regress the abnormal return from the announcement day to 60 days after the announcement (BHAR[0,60]) onto the return of the announcement day (BHAR[0,1]). The slope in these regressions has an interpretation as a signal-to-noise ratio.

To formalize the econometric analysis, let $t = -1$ correspond to the time just before the announcement, $t = 0$ the announcement date, and $t = T$ the revelation date of the asset's equilibrium value. At $t = -1$, the stock price $P_{-1} = \mathbb{E}(P_T)$ and at time $t = 0$, $P_0 = \mathbb{E}(P_T|I_0)$, where I_0 is the information revealed about the equilibrium value of the asset from the earnings announcement. I assume P_T to be the stock price "fair" or

equilibrium value, where $T = 60$. The interesting question is how much of the information I_0 is reflected in the observed price on the announcement date and how it changes over time. This will depend on the quality of the information revealed and the speed at which market participants process the information.

Let $(P_{j,T} - P_{j,-1})/P_{j,-1} = BHAR[0,60]$ and $(P_{j,0} - P_{j,-1})/P_{j,-1} = BHAR[0,1]$. Formally, the unbiasedness regression is specified as

$$BHAR[0,60]_{i,j} = \alpha + \beta BHAR[0,1]_{i,j} + \varepsilon_{i,j}. \tag{6}$$

If prices are perfectly efficient, the regression slope (β) should always be one, indicating prices follow a martingale. A slope greater than or less than one indicates price under-reaction and over-reaction, respectively.

Figure 10, Panel A, presents the estimated slopes of the unbiasedness regression since 1990 using 2-year rolling regressions for the full sample, all-but-microcap stocks, and microcap stocks. I begin in 1990 because of the small number of stocks with analyst coverage before 1990 in I/B/E/S. For the full sample, I find a downward trend in β over time, from approximately 1.4 in 1990 to 1.2 in recent years; indicative of a decline over time in stock price under-reaction on announcement dates relative to one-quarter ahead prices. A more striking downward trend emerges when observing the slopes for all-but-microcap stocks, from 1.6 to almost one in recent years. Thus, announcement day prices for these stocks are approximately martingale. This result further reinforces my prior findings that price discovery generally takes place at the time of the announcement. For microcap stocks, however, the figure shows no trends in the estimated slopes. Whereas prices of these stocks present close to no post-announcement drifts after conditioning on earnings surprises over time, prices do not fully reflect all the earnings news at the time of announcements. What information prices have yet to incorporate for microcap stocks is subject to an interesting avenue for future research.[17]

Panel B in Figure 10 reports the R^2 of the unbiasedness regressions specified in Equation (6) and indicates whether the informational content of prices on announcement dates has improved over time.[18] Before the

[17] I also find similar trends for the Compustat sample (see Figure IA.1 of the Internet Appendix).

[18] Analogous to the R^2, Biais *et al.* (1999) refer to the root mean squared error of the regression as a measure of informational content.

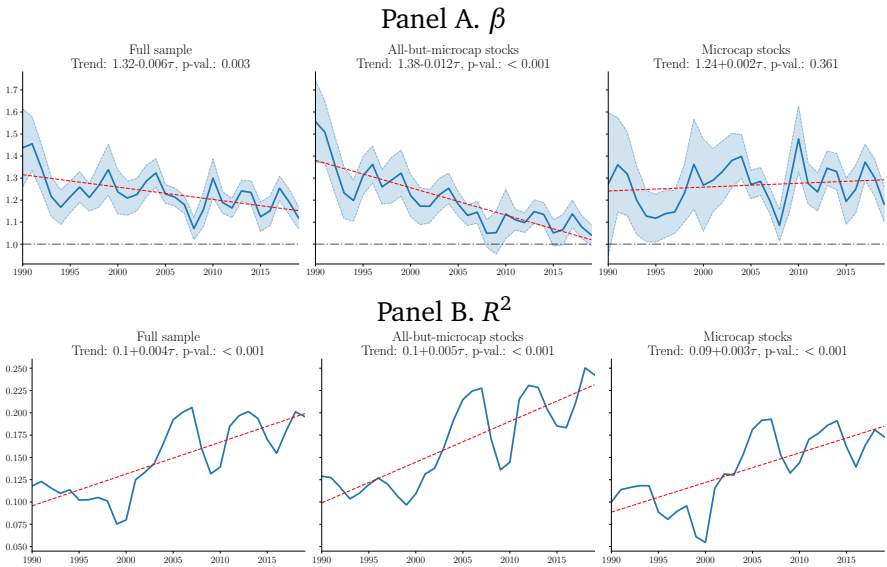

Figure 10: Unbiasedness regressions

Description: This figure shows the estimated coefficient (β) in Panel A and the explanatory power (R^2) in Panel B of the following 2-year rolling regression:

$$BHAR[0,60]_{i,j} = \alpha + \beta BHAR[0,1]_{i,j} + \varepsilon_{i,j},$$

where $BHAR[0,1]$ and $BHAR[2,60]$ are the stock i's earnings announcement j buy-and-hold abnormal returns on earnings announcement date and post-announcement, respectively. See Figure 5 for the definition of BHAR. The results are reported for the full sample, all-but-microcap, and microcap stocks from the I/B/E/S sample (i.e., firms with analyst coverage). Microcap stocks are those with market capitalization smaller than the NYSE 20th percentile. Above each plot is a linear time trend τ (red dotted line) with p-value based on Newey-West standard errors with five lags. The sample period is from January 1, 1990 to December 31, 2019.

Interpretation: The β for all-but-microcap stocks converges towards one over time, indicative that stock prices on announcement dates are close to martingale. The increase in R^2 over time suggests that announcement date prices are more informative about one-quarter ahead prices.

turn of the century, earnings announcements contain information about future prices where the R^2 for the full sample is approximately equal to 10% across the different samples. Between 2001 to 2005, I observe an abrupt increase in R^2 to approximately 20%. In recent years, the R^2 for all-but-microcap and microcap stocks is about 25% and 20%, respectively. This substantial increase in R^2 indicates a significant reduction in uncertainty about future prices and corroborates the results of Ball and Shivakumar (2008) and Beaver *et al.* (2020). The authors examine if the increase in firm disclosures on announcement dates (e.g., earnings guidance) translates into an increase in stock prices' informational content and find supportive results linking price informativeness and firm disclosures. Better firm disclosure is a plausible reason why today's stock prices generally better reflect the information content of earnings news at the time of the announcement.

6 Conclusion

This paper examines the evolution of price efficiency following earnings announcements over more than 40 years. Earnings announcements have long been associated with slow price formation, commonly known as the post-earnings announcement drift phenomenon. I find financial markets have become more efficient at incorporating earnings surprises at the time of announcements, and post-announcement price drifts have significantly weakened over time. In recent years, earnings surprises fail to predict post-announcement returns and price discovery generally occurs all on the announcement date. Studies examining price formation following earnings announcements at the daily and monthly horizon remains prevalent. In light of the findings presented in this paper, an important future avenue for such research is to examine intraday the role of trading frictions in price discovery at the time of announcements.

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	Authors	Journal	Friction	Suprise	Return	Period
1	Abarbanell and Bernard (1992)	JF	Failure to characterize the time-series properties of earnings	A, RW	S	1976-1986
2	Affleck-Graves and Mendenhall (1992)	JFE	Value Line's timeliness ranks	A, RW	S	1982-1986
3	Arif *et al.* (2019)	JAE	Concurrent release of EA/10-Ks (investor attention)	A	S	1995-2016
4	Ayers *et al.* (2011)	TAR	Trading activities of distinct sets of investors	A, RW	S	1993-2005
5	Balakrishnan *et al.* (2010)	JAE	Market failure to assess loss/profit	RW	S	1988-2005
6	Bartov (1992)	TAR	Unexpected earnings' patterns	RW	S	1979-1987
7	Bartov *et al.* (2000)	TAR	Investor sophistication	RW	S	1989-1993
8	Basu *et al.* (2010)	RAS	Expected inflation in earnings forecast	RW	S	1984-2005
9	Bathke Jr *et al.* (2019)	CAR	Investor overreaction	RW	S	2001-2012
10	Battalio *et al.* (2012)	JAE	Investors ignoring accrual information	A, RW	S	1990-1999
11	Ben-David *et al.* (2021)	MS	Institutional investor attention	A	S	2010-2015
12	Bernard and Thomas (1989)	JAR	Delayed price response to earnings news	A	S	1974-1986
13	Bhushan (1994)	JAE	Transaction costs	RW	S	1974-1986
14	Boehmer and Wu (2013)	RFS	Short selling	A	S	2005-2007
15	Boulland *et al.* (2017)	RF	Information intermediaries (investor attention)	A	S	1991-2010
16	Calluzzo *et al.* (2019)	MS	Institutional trading	RW	S	1982-2014
17	Campbell *et al.* (2009)	JFE	Institutional trading	A	P	1995-2000
18	Cao and Narayanamoorthy (2012)	JAR	Earnings volatility	A	S	1987-2008
19	Cao *et al.* (2017)	JFQA	Institutional investment constraints	A	S	1980-2013
20	Chan *et al.* (1996)	JF	Slow incorporation of past information	A, RW	P	1977-1993
21	Chen *et al.* (2011)	CAR	Investors delay in processing time-varying earnings persistence	RW	S	1975-2004
22	Chen *et al.* (2017)	CAR	Transaction costs	A, RW	S	1983-2014
23	Chi and Shanthikumar (2017)	TAR	Local bias	A, RW	S	2005-2011
24	Choi (2000)	JFQA	Value Line Investment Survey recommendations	RW	P	1965-1996
25	Chordia and Shivakumar (2005)	JAR	Inflation illusion	RW	P	1971-2001
26	Chordia and Shivakumar (2006)	JFE	Intra-industry information transfers	A, RW	S	1993-2006
27	Chordia *et al.* (2014)	JAE	Transaction costs	RW	P	1983-2011
28	Chung and Hrazdil (2011)	CAR	Limits to arbitrage	A	S	1993-2004
29	Collins and Hribar (2000)	JAE	Accruals	RW	P	1988-1997
30	Core *et al.* (2006)	RAS	Managers' repurchases and insider trading	RW	S	1989-2001
31	DellaVigna and Pollet (2009)	JF	Investor inattention on Fridays	A	S	1995-2006
32	Dou *et al.* (2016)	CAR	Cultural dimensions	A	S	1995-2008
33	Doyle *et al.* (2006)	JAR	Definition of earnings surprises and transaction costs	A, RW	S	1988-2000
34	Drake *et al.* (2015)	RAS	Information acquisition	RW	S	2008-2011
35	Elgers *et al.* (2001)	TAR	Delayed response to annual analysts' earnings forecasts	A	S	1982-1998
36	Elgers *et al.* (2008)	JAE	Measurement errors in the use of realized earnings changes	RW	S	1975-2003
37	Feldman *et al.* (2010)	RAS	Tone in disclosures	A	S	1993-2007
38	Frederickson and Zolotoy (2016)	TAR	Investor inattention	A	S	1985-2006
39	He and Narayanamoorthy (2020)	JAE	Investors ignoring earnings acceleration	RW	S	1972-2015
40	Henry and Leone (2016)	TAR	Disclosure tone	A	S	2004-2012

(*Continued*)

Table A.1: List of papers examining the relation between earnings surprises and stock returns following earnings announcements

Table A.1: *(Continued)*

	Authors	Journal	Friction	Suprise	Return	Period
41	Hirshleifer *et al.* (2009)	JF	Information overload (investor inattention)	A	S	1995-2004
42	Hirshleifer *et al.* (2008)	TAR	Naive trading by individual investors	RW	S	1991-1996
43	Huang *et al.* (2018)	TAR	Headline Salience (investor attention)	A, RW	S	1998-2008
44	Hung *et al.* (2015)	RFS	Financial reporting quality	A	S	2001-2009
45	Jegadeesh and Livnat (2006)	JAE	Revenue information	RW	S	1987-2003
46	Jiang and Zheng (2018)	RFS	Investor sophistication	RW	P	1984-2014
47	Kang *et al.* (2017)	CAR	Investors' underreaction to firms with foreign operations	A, RW	S	1990-2013
48	Kaniel *et al.* (2012)	JF	Informed trading	A	S	2000-2003
49	Ke and Ramalingegowda (2005)	JAE	Institutional investor trading	RW	S	1986-1999
50	Kim and Kim (2003)	JFQA	Model specification for risk-adjusted returns	RW	S	1984-1999
51	Kimbrough (2005)	TAR	Conference calls	A, RW	S	1994-2000
52	Kottimukkalur (2019)	JFQA	Investor attention	A	S	1995-2016
53	Kovacs (2016)	CAR	Investor underreaction to intra-industry information	A, RW	S	1993-2006
54	Lasser *et al.* (2010)	CAR	Level of short interest	A	S	1992-2003
55	Lee (2012)	CAR	Quarterly report readability	A	S	2001-2007
56	Li (2011)	RAS	Investors understanding of loss persistence	A, RW	S	1984-2006
57	Li *et al.* (2020)	RAS	Delayed disclosure and investor attention	A, RW	S	1990-2013
58	Liang (2003)	RAS	Information processing biases	A	S	1989-2000
59	Livnat and Mendenhall (2006)	JAR	Earnings surprise definition	A, RW	S	1987-2003
60	Loh and Warachka (2012)	MS	Streaks in earnings surprises biasing investors' expectations	A	S	1984-2009
61	Louis *et al.* (2008)	RAS	Accrual disclosure	RW	S	1999-2002
62	Ma and Markov (2017)	CAR	Market's assessment of meeting / beating consensus	RW	S	1993-2010
63	McLean and Pontiff (2016)	JF	Academic research	RW	P	1974-2013
64	Mendenhall (2002)	JAR	Earnings autocorrelation	RW	S	1983-1999
65	Michaely *et al.* (2016)	JAE	Timing of earnings announcements	A	P	1999-2013
66	Narayanamoorthy (2006)	JAR	Accounting conservatism	RW	S	1978-1998
67	Ng *et al.* (2008)	JAR	Transaction costs	A, RW	S	1988-2005
68	Ng *et al.* (2013)	RAS	Credibility of management forecasts	A	S	1995-2008
69	Porras Prado *et al.* (2016)	RFS	Firm ownership structure	A	S	2006-2010
70	Rangan and Sloan (1998)	TAR	Investors ignoring the auto-regressive structure in earnings	RW	S	1971-1994
71	Richardson *et al.* (2010)	JAE	Risk and transaction costs	RW	P	1979-2008
72	Sadka (2006)	JFE	Transaction costs	RW	S	1983-2001
73	Schaub (2018)	JFQA	Information intermediaries (investor attention)	A	S	1995-2011
74	Shane and Brous (2001)	JAR	Investor and analyst underreaction to future earnings	A	S	1977-1986
75	Truong and Corrado (2014)	RAS	Options trading volume	A	S	1996-2009
76	Vega (2006)	JFE	Public and private information	A	S	1986-2001
77	You and Zhang (2009)	RAS	Reporting complexity in SEC filiings	A	S	1995-2005
78	Zhang (2012)	TAR	Management forecasts accuracy	A	S	1995-2007
79	Zhang (2008)	JAE	Responsiveness of analyst forecasts to current earnings	A	S	1996-2002
80	Zhang *et al.* (2013)	JAE	Information risk and transaction costs	RW	S	1993-2007

Description: This table list the papers retrieved from Web of Science that directly examines the relation between earnings surprises and stock returns following earnings announcements. The articles are from the following journals: Journal of Finance (JF), Journal of Financial Economics (JFE), Review of Financial Studies (RFS), Journal of Financial and Quantitative Analysis (JFQA), Review of Finance (RF), Journal of Accounting Economics (JAE), Journal of Accounting Research (JAR), The Accounting Review (TAR), Review of Accounting Studies (RAS), Contemporary Accounting Research (CAR), and Management Science (MS). The column Friction list the main friction/factor examined in the paper intermediating the relation between the dynamics of price formation following earnings announcements and earnings surprises. In the column Surprise, "A" corresponds to analyst earnings surprises and "RW" corresponds to random-walk earnings surprises. In the column Return, "S" corresponds to stock-level returns (e.g., individual stock buy-and-hold or cumulative returns) and "P" corresponds to portfolio returns (i.e., long-short portfolios). The column Period corresponds to the sample period of the study. In total there are 80 articles retrieved from 1989 to 2020 (October) among the articles retrieved from the search of (post-earnings announcement drift OR announcement drift OR price formation) AND earnings in Web of Science.