Insider trading and the post-earnings announcement drift

By

Christina Dargenidou, Ian Tonks, and Fanis Tsoligkas*

October 2017

Abstract:

We show that trades by corporate insiders after an earnings announcement determine in part the extent of the post-earnings announcement drift anomaly. Contrarian trades mitigate the under-reaction to earnings announcements, and confirmatory trades allow for price discovery with price movements continuing in the same direction of the earnings surprise. These results are consistent with insider trading being a mechanism that provides relevant information on transitory or permanent changes to the earnings process allowing the market to make appropriate inferences about the nature of the earnings surprise.

Keywords: Insider trading, earnings announcements, market under-reaction, market efficiency

JEL classification:
G14, M41

Christina Dargenidou, Xfi Centre for Finance and Investment, University of Exeter, Rennes Drive, Exeter, EX4 4ST. Email: C.Dargenidou@exeter.ac.uk.

Ian Tonks, School of Management, University of Bath, Claverton Down, Bath, BA2 7AY, UK. Email: I.Tonks@bath.ac.uk.

Fanis Tsoligkas, School of Management, University of Bath, Claverton Down, Bath, BA2 7AY, UK
Email: F.Tsoligkas@bath.ac.uk.

We gratefully acknowledge helpful comments and discussion received from George Bulkley, Clive Lennox, Per Olsson, Beatriz García Osma, and seminar participants at the Financial Markets and Corporate Governance Conference, Wellington, April 2017, *JBFA* Capital Markets Conference, Hong Kong Polytechnic, May 2017, Universities of Bath, Exeter, King's College London, Auckland University of Technology, National University of Singapore, Hong Kong, HKUST, and WHU – Otto Beisheim School of Management.

1 Introduction

This paper examines the consequences of trading by corporate insiders on the well-documented post-earnings announcement drift (PEAD) anomaly, whereby large positive unexpected earnings (UE) announcements are followed by an upwards drift in security returns, and large negative UE are followed by a downwards drift. The PEAD represents an under-reaction to earnings surprises, predominantly in those stocks with the largest surprises, for both positive (good news) and negative (bad news) announcements. Using a sample of 7,980 annual earnings announcements in the U.K. over the period 1995-2013, we first report evidence of the PEAD phenomenon: the spread in returns between the top and bottom quintiles formed on the basis of UE is a significant 3.4% six months after the earnings announcement. We go on to argue that corporate insider trading in the period after the earnings announcement affects the market's learning process of whether a structural change in the earnings series has occurred by providing additional information to the market about the interpretation of the earnings surprise. We show that information in contrarian directors' trades after an earnings announcement - director sales after good news or director buys after bad news - mitigate the PEAD. The market observes the trading behaviour of directors and infers that the earnings surprise reflects only a transitory change in earnings. Conditioning on these contrarian directors' trades, we find that the top to bottom quintile spread is reduced to an insignificant -1.4% six months later. In contrast, those companies with confirmatory director trades (in the same direction as the earnings surprise: director sales after bad news or director buys after good news) are deemed by the market to signal that there has been a permanent shift in earnings but the magnitude is difficult to determine. The post-earnings quintile spread in these companies that display confirmatory directors' trades increases to a highly significant 7.3%. This exacerbated PEAD represents price discovery as the market learns about the values of the new parameters in the earnings process. In the absence of any directors' trades, the market remains uncertain about the structural break. Our evidence on the market response to the joint signals of an earnings surprise and subsequent directors' trades suggests that the PEAD represents a learning response to the identification of permanent and transitory changes in the earnings process.

Seeking to explain the PEAD anomaly, Bernard and Thomas (1990) attribute it to the failure of stock prices to fully reflect the implications of time series properties of earnings for

future earnings.[1] Taking further the hypothesis that PEAD is caused by investors' inefficient use of information to predict future earnings, subsequent research ascribe the anomaly to: unsophisticated investors' trades (Bartov, Radhakrishnan and Krinsky, 2000), the underestimation of the implications of inflation (Chordia and Shivakumar, 2005), accounting conservatism (Narayanamoorthy, 2006) as well as poor disclosure readability (Lee, 2012). Recent research by Milian (2015) documents that the PEAD anomaly persists, albeit concentrated over a shorter period of time. A possible explanation for the pervasiveness of PEAD may arise from cognitive biases preventing investors from fully reacting to the new information in the earnings surprise, including limited attention (Hirshleifer, Lim and Teoh, 2009), investors' overconfidence in their private beliefs (Liang, 2003) and limits to arbitrage (Ng, Rusticus and Verdi, 2008). Alternatively, what appears to be a delayed reaction to the implications of current earnings for future earnings could be an implication of investors' learning or ''rational structural uncertainty'' (e.g. Francis, Lafond, Olsson and Schipper, 2007). Learning models predict that investors under-react to information signals after a structural shift has occurred, because there is uncertainty as to whether a structural shift has in fact happened. Brav and Heaton (2002) note significant similarities in the underpinnings of behavioural and rational learning theories, and caution that it may be difficult to distinguish between them.

In a similar vein, we argue that trading by corporate insiders provides information that investors use to address the inference problem as to whether a structural shift in the earnings process has occurred. Investors who observe the direction of corporate insider trading are able to infer directors' private information about the earnings surprise. We follow Seyhun (1998) and identify a set of contrarian insider trades, taking place after the earnings announcement but in the opposite direction to the sign of the earnings surprise. These trades provide a signal to the market that the earnings surprise denotes a transitory realization, and the market's response reverses the initial reaction to the earnings announcements. The remaining set of insider trades occur in the same direction as the earnings surprise which we classify as confirmatory trades. These trades signal that informed insiders believe that the earnings surprise represents information about a permanent change in the earnings process. The market updates its beliefs about the permanent-transitory nature of earnings on the basis of this additional information and in the case of confirmatory directors' trades, the initial under-reaction to the earnings

[1] A comprehensive literature review of the PEAD can be found in Richardson, Tuna and Wysocki (2010) and Kothari (2001). The PEAD is illustrated in Figure 1 by the upward drift in returns represented by the unconditional good news PEAD box following a positive earnings surprise. The downward drift in returns following a negative earnings surprise is illustrated by the position of the unconditional bad news PEAD box.

surprise adjusts as prices continue to move in the same direction as the surprise, representing price discovery.[2]

Francis et al. (2007) predict that the under-reaction to earnings announcements is negatively associated with the level of the precision of the earnings signal, because investors' learning is delayed when the earnings signal is less precise. We extend this argument and examine the effect of interacting the precision of the earnings signals with corporate insider trading. We demonstrate that in the presence of contrarian insider trading after the earnings announcement, there is no under-reaction to earnings announcements in firms with low earnings precision. The implication is that in these hard-to-value cases, contrarian directors' trades allows the market to interpret the earnings surprise as a temporary event. In contrast, we find that in the presence of confirmatory trading the under-reaction is still significant. This suggests that confirmatory trades initiate a learning process to establish the extent of the permanent shift in the earning process even under circumstances where this is not likely to occur, i.e., under high earnings precision.

Our research contributes to the literature examining the implications of insider trading disclosure for the valuation of corporate earnings. To date, this research has indicated that the information contained in directors' trading allows the market to develop inferences about future earnings. For instance, Udpa (1996) shows that insider trading prior to an earnings announcement mitigates the market reaction to the subsequent earnings announcement. In a similar vein, Roulstone (2008) reports that insider purchases and sales result in lower market reaction during the earnings announcement. Beneish and Vargus (2002) find that the discretionary component of accruals in earnings is more persistent when accompanied by directors' purchases and less persistent when accompanied by sales. More recently, Choi, Faurel and Hillegeist (2017) show that the market uses pre-announcement insider trading information to anticipate and interpret the current earnings news leading to improved stock price efficiency during the post-earnings announcement period. In contrast to this stream of research, we are interested to find out how the market employs the information in directors' trading that occurs *after* the earnings announcement.

Kolasinski and Li (2010) examine insider trading after the earnings announcement. However, they focus on whether insiders exploit the initial under-reaction to an earnings

[2] Veenman (2012) also distinguishes between insider confirmatory buys after good news, and contrarian buys after bad news.

announcement. Our study is mostly related to Veenman (2012) who investigates the short-term market reaction to the post-earnings announcement disclosure of insider purchases. Veenman (2012) finds that insiders' purchases enable the market to resolve the uncertainty associated with the valuation of past reported earnings. We differ from Veenman (2012) by investigating the implications of insider trading for the post-earnings announcement drift. This allows us to demonstrate that insider trading does not simply trigger a short-term market reaction but instead, initiates a learning process of uncertainty resolution with respect to whether a structural change in the earnings series has occurred.

The remainder of the paper is structured as follows: in Section 2 we discuss the regulation and practices with respect to insider trading around earning announcements in the UK. In Section 3 we develop our hypotheses concerning the impact of insider trading on the post-earnings announcement drift. In Section 4, we discuss the methodology that we employ to test our hypotheses, and in Section 5, we describe the data and the construction of our variables. In section 6 we report our findings, and finally in Section 7, we present the conclusions to the study.

2 Insider trading around earnings announcements: Regulation and practices in the UK

The regulatory framework and common practices in the UK allow us to determine the timing of transactions which are most likely to convey insiders' private information about the interpretation of the earnings surprise. The UK provides a unique setting for our investigation since the institutional arrangements allow first, directors to trade immediately after the earnings announcement and associated trading ban, and second, a speedy disclosure of transactions.

Insider trading on price sensitive information and in particular the trades by directors in the UK are regulated by The Companies Act 1985, The Criminal Justice Act (CJA) 1993, The Financial Services and Markets Act (FSMA) 2000, Listing Rules and Disclosure Rules administered by the Financial Conduct Authority, who may impose penalties such as fines or imprisonment to insiders found guilty of trading on inside information. The London Stock Exchange Model Code (1977) (part of the Listing Rules), requires directors who trade in their own company's shares first, to seek clearance to trade from the Board ahead of the transaction and second, to report their trades to the company no later than the fourth day after the

transaction occurred. [3] In turn, the company must notify the Stock Exchange no later than the following day, when the information about the trade is disseminated to the market. Although the duration of this process appears to be lengthy, in practice, the disclosure of insider trades in the UK is very timely. Fidrmuc, Goergen and Renneboog (2006) report that 85% of the directors' trades in the UK are announced to the market either on the same day they occur or on the following day. This is confirmed in our data, with 82.11% of the shares traded within the first 10 trading days after and including the earnings announcement day, being disclosed on the same or following day.

In addition, the Model Code prescribes a clearly-defined and well observed trading ban,[4] forbidding insiders from trading for two months prior to the earnings announcement. The purpose of this trading ban is to prevent insiders from exploiting any private information with respect to the forthcoming earnings announcement. However, an insider may trade after the end of the trading ban, with the trading restriction ending immediately after the earnings announcement has been made public. Our analysis will focus on these directors' transactions taking place shortly after the earning announcement.

3 Hypothesis development

In this section we develop our hypotheses concerning the impact of corporate insider trading on the post-earnings announcement drift – the market's under-reaction to earnings announcements. We argue that trading by corporate insiders allows the market to make improved inferences about changes in the underlying earning process and that such revisions can partly explain the PEAD. Bulkley and Tonks (1989), Timmermann (1996), and Veronesi (1999) have shown that since standard valuation models rely on estimates of the growth process for dividends and earnings as inputs, small revisions to these growth estimates can generate large changes in equity values which can explain the observed excess volatility of stock prices. Investors form expectations of future fundamentals such as earnings or dividends based in part on the time series properties of previous fundamentals. They update their beliefs about these estimates as new data on dividends and earnings become available. When a large surprise in

[3] Insiders in the UK are normally interpreted to be executive and non-executive directors of the company. Thus, we use the terms "insiders" and "directors" interchangeably to refer to corporate insiders.
[4] These listing rules apply to firms on the Main Market and on AIM. The trading ban in the UK has been shown to be well observed (e.g. Korczak, Korczak and Lasfer, 2010) with directors either abstaining from trading during this period, or trading with the permission of the company chairperson.

earnings is announced, whether positive or negative, investors must decide whether this change represents a transitory or permanent variation in earnings. If the nature of the change in earnings is transitory, then the value of the company will only change by the contemporaneous change in the most recent earnings level. For instance, Freeman and Tse (1992) show that transitory earnings have small or no impact on prices. On the other hand, if a structural change has occurred in the earnings process, then the announced earnings represent the first realisation from a new earnings process, and the value of the firm should change to reflect the new earnings process. From the perspective of a learning model, investors face an identification problem from the most recent earnings figure, as to whether the unexpected value is an outlier from the previous earnings process, or is the first observation in a new earnings series. As well as explaining excess volatility puzzles, learning models in finance have been applied to explain asymmetric time-varying volatilities (David, 1997), the equity risk premium (Brennan and Xia, 2001), the value premium (Pástor and Veronesi, 2003), and term structure puzzles (Bulkley and Giordani, 2011). Lewellen and Shanken (2002) develop an equilibrium rational learning model where Bayesian-investors under-react to information signals after a structural shift has occurred, because there may be some uncertainty as to whether a structural shift has in fact happened. If there has been a structural shift, then investors face the difficult problem of valuing a new income stream with new parameters. Lewellen and Shanken (2002) suggest that many stock market anomalies can be explained by rational learning about parameter uncertainty but argue that this does not mean that there are exploitable arbitrage opportunities because "the strategy earns abnormal profits in a frequentist sense, but not from the Bayesian perspective of investors" (p. 1125). Brav and Heaton (2002) also note that it may be difficult to distinguish between rational learning and behavioural explanations for stock market anomalies.[5]

In an environment with parameter uncertainty investors will look around for further information that will allow them to make a better inference on the transitory or permanent shock to earnings. One such source of information is the trading behaviour of corporate insiders, who are allowed to trade after the earnings announcement in the UK following the relaxation of the two-month prior trading ban. Insider trading is a mechanism that enables private information held by corporate insiders to be incorporated into stock market prices

[5] These learning models do not distinguish between learning and imitating. Acemoglu, Dahleh, Lobel and Ozdaglar (2011) incorporate social networks into a sequential learning model, and demonstrate even when there are an influential group of agents whom other agents copy, there will still be an asymptotic convergence to the efficient outcome (no herding) provided that the information signals received by individuals are unbounded.

(Manne, 1966). We argue that after an earnings announcement, large earnings surprises may reflect either an extreme value from existing distribution, representing a transitory component to earnings, or a value from new distribution, representing a structural change in the earnings process. Investors must assess whether a structural change has occurred.[6] Bayesian investors update beliefs from sample information generated by the relevant distribution, and directors' trades after the earnings announcement represent that sample information. We assume that directors with private information about the fundamental value of their firm, trade to maximise their wealth.[7] They will buy (sell) shares when the market price undervalues (overvalues) their estimate of the firm's fundamental value. This behaviour is consistent with the empirical evidence which demonstrates that information in directors' trading is associated with significant market reactions in both the short run (Fidrmuc et al., 2006) and long run (Lakonishok and Lee, 2001). Further, work by Seyhun (1998), and Hillier and Marshall (2002) has established trading patterns around the earnings announcement that illustrate insiders' informational advantages. Contrarian directors' trades in the post-earnings announcement period imply that corporate insiders know the earnings surprise is a transitory event, and that current prices are driven by an over-reaction to the earnings surprise. The market infers that the earnings surprise reflects a transitory change in earnings, and there will be no PEAD. On the other hand, confirmatory directors' trades, in the post-announcement period reveal that insiders know the earnings surprise represents a permanent structural change. The market will correctly infer that there has been a permanent change in the earnings process, although the parameters of this new distribution will need to be estimated.

Seyhun (1998) notes that an insider who wants to purchase shares and anticipates a negative earnings surprise will hold back from trading until after the bad news has been announced in order to buy shares at a lower price. Conversely, an insider who wishes to sell and anticipates a positive earnings surprise will again postpone trading until after the public announcement, in order to sell at a higher price. These contrarian trading patterns are motivated by insiders' information that the earnings surprise represents a transitory event. Specifically,

[6] In Appendix 1 we provide a simple example of a shock to an earnings process generated by a uniform distribution, which reveals a structural change with an unknown upper support. Conjugate prior beliefs on this unknown parameter are represented by a Pareto distribution, meaning that investors who update from the likelihood function according to Bayesian rules will have posterior beliefs that are also Pareto. We show that such a learning mechanism generates a price process that replicates a PEAD.

[7] Bagnoli and Watts (2007) model managers' disclosure strategy around earnings announcements, and show that the optimal strategies are asymmetric around good and bad news, reflecting transitory and permanent components. However, an underlying assumption in Bagnoli and Watts (2007) is that the manager selects a voluntary disclosure strategy to maximize the market price of the firm. In our setting, we assume that managers trade to exploit their information advantage for their own benefit.

Seyhun (1998) argues that "Following their sales, insiders do not necessarily expect negative future performance. They only know that past expectation of good performance is completed and the stock price fully reflects insiders' expectations." (p 51). Following Seyhun (1998), we argue that the contrarian direction of these insider trades reveals that prices have over-reacted to the information in the earnings surprise, with the implication that such earnings surprises represent only a transitory change in earnings. The contrarian nature of these trades provides a contradictory signal to the earnings surprise, and causes market participants to revise their expectations in the opposite direction to the sign of the earnings surprise. The joint signal of an earnings surprise and a contrarian directors' trade, allows investors to infer that the earnings surprise does not reflect a permanent change in earnings, and we would not expect any further price movement in the direction of the earnings surprise; in fact, PEAD will be dissipated. Following these discussions, we set out our first hypothesis:

Hypothesis 1 (H1): Informed contrarian directors' trading after an earnings announcement conveys a signal on the transitory nature of the earnings surprise that attenuates the PEAD.

Figure 1 illustrates the pattern in returns that we predict following either of two joint signals: (positive earnings surprise and directors' sells) or (negative earnings surprise and directors' buys). In both cases we expect the initial stock price reaction to the earnings surprise to represent an over-reaction which is then mitigated by the contrarian trades, represented by the attenuated PEAD boxes.

FIGURE 1 ABOUT HERE

We now turn to the other type of insider trading around the earnings announcement: confirmatory insider trades. Confirmatory insider trades are those directors' trades that occur after the earnings announcement and in the same direction as the sign of the earning surprise, and are also illustrated in Figure 1. From these trades investors infer that there has been a permanent shift in the earnings process, since with confirmatory trades informed insiders are either buying shares after the good earnings news, or selling shares after the announcement of a bad earnings surprise. In both cases confirmatory directors' trading reveals a mis-valuation of the underlying firm fundamentals, and that the initial price reaction was an under-reaction to the earnings surprise. The direction of these confirmatory trades indicate that prices have still to fully reflect the information in the earnings surprise. This behaviour is consistent with the latest earnings surprise figure representing a permanent change to the earnings process.

However, there are two issues in relation to the inferences that the market makes from confirmatory directors' trades.

First, the absolute upper limit on the permanent change in earnings is undefined whether for good news or bad news. Although the market may infer from these trades that there has been a permanent change in earnings, the parameters of this new earnings process are not yet known, and there is still much uncertainty about the ultimate equilibrium share price.[8] Although the joint signal of confirmatory trades and the earnings surprise indicates that a structural break has occurred, it is well-known that analysts typically under-estimate the extent of earning changes (e.g. Abarbanell and Bernard, 1992). Further, Ali, Klein and Rosenfeld (1992) show this under-estimation is more severe when earnings are deemed permanent. It is therefore unlikely that with a joint signal of an earnings surprise and a confirmatory insider trade prices will immediately jump to a new equilibrium level. It is more likely that there will be subsequent drift to the new equilibrium given that even professional investors (e.g. analysts) under-estimate the permanence of the structural change.

Second, insiders have reduced incentives to engage in confirmatory trading after the earnings announcement, given that the earnings surprise reveals in part the insiders' information. Directors would have greater incentives to trade prior to the earnings announcement to fully exploit their private information about the forthcoming earnings surprise. In the context of the UK's two month trading ban, an insider would purchase (sell) shares before the announcement of a positive (negative) earnings surprise, just prior to the imposition of the trading ban. However, pre-earnings announcement insider trading is rare as it exposes insiders to both litigation and reputation costs. Hillier and Marshall (2002) report that although insiders with private information about the upcoming earnings announcement may trade prior to the start of the trading ban period, the transparency of the trading disclosures and the legal consequences means that such trades are uncommon. Piotroski and Roulstone (2007) show that insiders refrain from pre-earnings announcement trades when the magnitude of the surprise is extreme. Also, there is evidence of a substantially higher incidence of directors' trading in the period following the earnings announcement, and this is consistent

[8] A similar issue arises in the case of insider trading around earnings restatements. Badertscher, Hribar and Jenkins (2011) argue that it is only possible to identify directional hypotheses about how stock prices respond to insider trading and accounting restatements, but not the rank order of the magnitude of the effects.

with insiders' reluctance to trade before the announcement and preference to delay their trades (Hillier and Marshall, 2002).

In summary, although the patterns associated with confirmatory insider trading are consistent with insiders exploiting their informational advantage over the interpretation of the earnings surprise, we anticipate the asymmetric incentives (compared with contrarian trades) may render a delayed stock market response to the earnings surprise. This discussion leads us to our second hypothesis:

Hypothesis 2 (H2): Informed confirmatory directors' trading after an earnings announcement conveys a noisy signal that a structural change in the earnings distribution has occurred, resulting in an exacerbated PEAD.

Figure 1 illustrates the predicted pattern in returns following confirmatory directors' trades. For both good and bad earnings surprises, the initial stock price reaction under-estimates the long-run fundamental price, and the subsequent stock price reaction is represented by the exacerbated PEAD boxes. The underlying conjecture in the development of hypotheses H1 and H2 is that the disclosure of informed directors' trading provides relevant information to the market which accelerates investors' learning with regards to the transitory-permanent nature of the earnings surprise and thus, either attenuates or exacerbates the reaction to the earnings announcement. We may seek further support for these arguments by examining these conjectures in relation to the characteristics in the earnings surprise related to the difficulty investors have in interpreting these signals. Francis et al. (2007) argues that a testable consequence of a rational learning model explanation of the PEAD is that we would expect the PEAD anomaly to be most prevalent in high information uncertainty firms whereby uncertainty is captured by the precision of earnings. They show that in these hard-to-value firms the under-reaction to earning announcements is exacerbated by the low precision in earnings signals since the investors' inference problem becomes more complex for these cases, and the speed at which investors incorporate the information in the earnings surprise is delayed. Veenman (2012) and Bhattacharya, Desai and Venkataraman (2013) extend these arguments and show that a low precision earnings signal amplifies the information asymmetry between insiders and outsiders, and increases the importance of insiders' private information for investors' assessments.

Hypothesis 3 then seeks to expand the evidence of the impact of contrarian and confirmatory trades conditional upon the influence of earnings precision:

Hypothesis 3:

(H3a): Contrarian insider trading attenuates the PEAD for low earnings precision (high information uncertainty) firm-announcements.

(H3b): Confirmatory insider trading exacerbates the PEAD for high earnings precision (low information uncertainty) firm-announcements.

The two parts to H3 seek to corroborate the learning mechanism underlying the impact of contrarian and confirmatory insider trading outlined in H1 and H2. In the case of contrarian trades, evidence of a mitigated PEAD under circumstances when it is most likely to occur, validates the suggested mechanism through which learning occurs. H3a predicts that in low precision firms, contrarian directors' trades will be effective at weakening the PEAD. We might anticipate a corollary of H2 with respect to confirmatory trades in high precision firms. We expect that in high earnings precision firms the PEAD will not be present, in which case if we find evidence of a PEAD following confirmatory directors' trades in such firms, this again will validate directors' trades as a learning mechanism. H3b predicts that in high precision firms, the presence of confirmatory insider trading will lead to a PEAD effect.

To summarise, our main hypotheses H1 and H2 are concerned with the role of informed contrarian and confirmatory insider trading in explaining the PEAD. Hypothesis H3 complements the first two hypotheses, since it aims to corroborate the role of insider trading in the context of low and high earnings precision firms, and thus validate that this learning mechanism is distinct from the learning that relies on fundamentals.

4 Research design

To investigate the effect of informed insider trading on the under-reaction to earnings announcements, we follow the event-study methodology to first identify the post-earnings announcement drift (e.g. Bartov et al., 2000) and then include variables that examine the impact of contrarian and confirmatory directors' trading on stock market returns. The timing of these events ensures that causality flows from the joint signal of the earnings surprise and directors' trades through to abnormal returns. Evidence of the under-reaction to earnings announcements is documented by a significant association between the earnings surprise and subsequent returns, as follows:

$$BHAR_{i,t} = \alpha_0 + \alpha_1 RUE_{i,t} + \alpha_2 Controls_{i,t} + \varepsilon_{i,t} \quad (1)$$

where, $BHAR_{i,t}$ denotes market adjusted buy-and-hold abnormal returns using the FTSE all share marked index measured from 11 days after the earnings announcement to six months later (day +126), where a month is defined in terms of 21 trading days, and RUE_{it} is the rescaled quintile rank of the earnings surprise. Our main results refer to the PEAD over an approximate 6-month trading horizon. We concentrate on this time period since Bernard and Thomas (1989) report "a disproportionately large fraction of post-announcement drift is concentrated in the few days preceding and including the next quarter's earnings announcement" (p. 30). In the US where most firms report on a quarterly basis the timing of the PEAD is often measured over a 3-month horizon to capture the next earnings announcement date. In the UK where semi-annual reporting is much more common, Liu, Strong and Xu (2003) report the existence of the PEAD over a range of time horizons, but concentrate their abnormal return tests on the 6-month horizon. In order to assess the robustness of our results to the timing effects, we undertake additional tests for PEAD returns measured at 2-month (+11 to +52), 3-month (+11 to +73), 4-month (+11 to +94) and 5-month (+11 to +115) time horizons.

We first calculate unexpected earnings defined as the quintile rank of the earnings surprise, where the cut-off points are determined by the distribution of the earnings surprise in the previous year. We define the earnings surprise based on the difference between actual earnings and the latest analysts' earnings forecast (e.g. Ayers, Li and Yeung, 2011). We follow Mendenhall (2004) and define $RUE_{i,t}$ as a variable taking the value "-0.5" when an observation belongs to the bottom quintile rank of earnings surprise and "0.5" when an observation belongs to the top quintile rank of earnings surprise. For the intermediate quintiles, we set $RUE_{i,t}$ to be equal to zero. In this case, the difference between the extreme earnings surprise quintiles is equal to unity and therefore, α_1 represents the spread in average abnormal returns between observations in the highest and lowest unexpected earnings surprise quintiles. Figure 1 shows how this spread is measured. In the case of a positive earnings surprise the unconditional PEAD is measured by the vertical distance represented by the GN_PEAD box. Similarly, an unconditional bad news PEAD is measured by the BN_PEAD box. The spread measures the difference between these two boxes: spread = [GN_PEAD – BN_PEAD].

We control for the risk factors and variables that have been shown to be relevant for the UK stock market (e.g. Jiang, Soares and Stark, 2016). These include (i) size measured as the market value of the company at the fiscal year end, (ii) book-to-market which is the ratio of common shareholder's equity to the market value of the company at the day of fiscal year end, (iii) momentum which is measured as the buy and hold market adjusted return over the six

months prior to the earnings announcement, (iv) the effect of R&D, captured by the ratio of R&D expense to the market value of the company, (v) leverage, measured as total debt divided by the market value of the company at the fiscal year end, (vi) the cash flow effect, captured by the ratio of operating cash flows to the firm's total assets, (vii) the natural logarithm of the share price at the begging of the accumulation period, and (viii) capital expenditures divided by the market value at the fiscal year end. In each case we control for these risk factors by means of the quintile rank of the corresponding variables (e.g. Hirshleifer, Myers, Myers and Teoh, 2008). In Appendix 2 we provide details on how these variables have been estimated.

Building on the evidence for the PEAD reported for the UK (e.g. Liu et al., 2003) and the US (e.g. Ayers et al., 2011), we predict a positive and statistically significant coefficient α_1 denoting an abnormal returns continuation along the sign of the earnings surprise $RUE_{i,t}$. In order to test Hypotheses H1 and H2, we adjust (1) by partitioning the association between the earnings surprise and subsequent returns in the presence of informed contrarian (*Ctrar*) and confirmatory (*Cfirm*) insider trading. Specifically, we modify (1) as follows:

$$BHAR_{i,t} = \beta_0 + \beta_1 Ctrar\_RUE_{i,t} + \beta_2 Cfirm\_RUE_{i,t} + \beta_3 NT\_RUE_{i,t} + \beta_4 Ctrar_{i,t} + \beta_5 Cfirm_{i,t} + \beta_6 Controls_{i,t} + \varepsilon_{i,t} \quad (2)$$

where, $Ctrar\_\mathrm{RUE}_{i,t}$ equals to $RUE_{i,t}$ when directors engage in contrarian trading after the earnings announcement, and zero otherwise; $Cfirm\_RUE_{i,t}$ equals to $RUE_{i,t}$ when directors engage in confirmatory trading after the earnings announcement, and zero otherwise; $NT\_RUE_{i,t}$ equals to $RUE_{i,t}$ when directors abstain from trading after the earnings announcement, and zero otherwise. We also include the main effects of $Ctrar_{i,t}$ and $Cfirm_{i,t}$ in order to control for the possible effect of contrarian and confirmatory trading on subsequent abnormal returns.

Hypothesis H1 postulates that contrarian insider trading conveys useful information on the transitory nature of the earnings surprise that attenuates the under-reaction to earnings announcements. Hence, we expect the coefficient β_1 to be insignificantly different from zero ($\beta_1 = 0$) indicating that the earnings surprise is not associated with a subsequent drift. H2 predicts that the presence of confirmatory insider trades will convey information about the permanent nature of the earnings surprise, which nevertheless, involves significant uncertainty and thus, there will be a continuation of the PEAD. Therefore, we expect the coefficient β_2 to

be positive and significant ($\beta_2>0$). Additionally, the absence of any insider trading implies that the additional information needed to allow the market to interpret the permanent-transitory nature of the earnings surprise is not available, and we might expect β_3 to be positive in line with the overall evidence on PEAD. The case of PEAD in the absence of insider trading will be further investigated when testing H3. Furthermore, we seek to corroborate the distinct role of directors' trading in promoting efficient stock prices as set out in H1 and H2 by comparing these coefficients, and we anticipate: $\beta_2 > \beta_3 > \beta_1$. Referring back to Figure 1, the conditional good news PEAD after contrarian insider trading is given by the GN_{ct}_PEAD box, and the conditional bad news contrarian PEAD is given by the BN_{ct}_PEAD box. So, the contrarian spread is the difference between these two boxes: Contr. Spread = [GN_{ct}_PEAD – BN_{ct}_PEAD]. Similarly, for the confirmatory spread: Conf. Spread = [GN_{cf}_PEAD – BN_{cf}_PEAD].

In order to test Hypothesis H3, we need to obtain an estimate of the earnings signal precision. Following Francis et al. (2007) we measure the earnings signal precision by means of the magnitude of discretionary accruals.[9] To construct our measure of earnings precision, we rank firms annually based on the magnitude of their discretionary accruals. We assign an earnings precision variable (PREC) which takes the value of 1 if a firm belongs to the bottom tercile of this ranking, and 0 otherwise. Observations ranked in the bottom tercile of the unsigned discretionary accruals' distribution are considered to exhibit high earnings signal precision (PREC=1) while the remaining observations are considered to exhibit low levels of precision (PREC=0).

Equation (3) then enables us to test H3 by examining the association between the earnings surprise and subsequent returns, as described in (2), conditioning on the earnings signal precision (PREC).

$$\begin{aligned} BHAR_{i,t} = {} & \gamma_0 + \gamma_1 Ctrar\_RUE_{i,t} + \gamma_2 Cfirm\_RUE_{i,t} + \gamma_3 NT\_RUE_{i,t} \\ & + \gamma_4 Ctrar\_RUE_{i,t} * PREC_{i,t} + \gamma_5 Cfirm\_RUE_{i,t} * PREC_{i,t} + \gamma_6 NT\_RUE_{i,t} * PREC_{i,t} \\ & + \gamma_7 Ctrar_{i,t} + \gamma_8 Cfirm_{i,t} + \gamma_9 PREC_{i,t} + \gamma_{10} Controls_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (3)$$

[9] The main tests in Francis et al. (2007) employ a model that relies on a long time series of data and is based on Dechow and Dichev (2002). However, they report similar results when using the proxy that we employ here (cf. page 427 of their paper).

The coefficients of particular interest in (3) are the coefficients γ_1 and γ_5. These coefficients represent respectively: the influence of contrarian insider trading in low earnings precision firms (*PREC=0*) where the PEAD is most prevalent; and the role of confirmatory insider trading in high earnings precision firms (*PREC=1*), where it has been shown that the PEAD is largely absent. Consistent with the distinctive ability of contrarian insider trading to facilitate investors' learning under low earnings precision, H3a predicts that γ_1 would be insignificantly different from zero. H3b predicts that even for high precision firms investors will be sensitive to the confirmatory directors' trades, and therefore we anticipate $\gamma_5 > 0$. In the absence of insider trading, we anticipate a negative and significant coefficient γ_6. This is because in the absence of insider trading, the information acquisition process is largely based on the underlying fundamentals as suggested by Francis et al. (2007).

5 Data and empirical proxies

5.1 Data

We collect data for all UK non-financial companies listed in both the MAIN and the AIM markets for the period between 1995 and 2013. This yields an initial sample of 19,804 observations. Requiring an intersection between Datastream and I/B/E/S Detail History files to collect the necessary data for estimating the earnings surprise variable, we lose 9,366 data points mainly due to missing earnings announcements.[10] We note that requiring this intersection between Datastream and I/B/E/S datasets introduces a selection bias against the inclusion of very small and illiquid companies without an analyst following. We define the earnings surprise as:

$$UE_{i,t}=(Actual\_EPS_{i,t}-Forecasted\_EPS_{i,t})/P_{i,t-1}$$

where, $Actual\_EPS_{i,t}$ is the actual earnings per share reported in I/B/E/S for year *t*; $Forecasted\_EPS_{i,t}$ is the single most recent forecast made by the timeliest analysts prior to the earnings announcement;[11], and $P_{i,t-1}$ is the stock price at the previous fiscal year end. We

[10] We require the annual final earnings announcements to be available in Datastream or I\B\E\S, and ignore any interim announcements. After eliminating earnings announcements announced more than 200 days after the fiscal year end, we supplement the earnings announcements in Datastream from I\B\E\S and choose the earliest given the concerns of I\B\E\S reliability (Hung, Li and Wang, 2014). Most UK companies also report interim earnings announcements after six months, but a small number report quarterly interim earnings announcements. We undertake a robustness check of our results and exclude the 75 firms that make quarterly announcements.

[11] Following Bartov, Givoly and Hayn (2002), we only consider the latest forecast preceding the earnings announcement by at least three days. Using the latest forecast is quite common (e.g. Bartov et al., 2002; Ayers et al., 2011) and is known to be more closely related to the market reaction at the earnings announcement (Brown

convert $UE_{i,t}$ into quintiles of earnings surprises based on the magnitude of the surprise. We acknowledge that not all companies announce earnings at the same time and the distribution of earnings surprises might not be known prior to the portfolio formation date. Therefore, we define the quintiles of the earnings surprises from the distribution of the preceding year's surprises. We further eliminate 2,044 observations due to missing market data from Datastream, and a further 7 observations are eliminated due to missing accounting data that are necessary for the calculation of discretionary accruals.[12] Trimming buy-and-hold abnormal returns as well as the variables involved in the estimation of the discretionary accruals at the 2st and 98th percentiles of their distributions reduces further the sample by 334 firm-year observations. These selection criteria yield a final sample of 7,980 firm-year observations from 1,373 different firms, of which 1,524 firm-year observations and 429 firms are AIM-listed. Table 1 summarises the sample selection procedure.

TABLE 1 ABOUT HERE

5.2 Abnormal returns

We measure the post earnings announcement returns as the buy-and-hold market adjusted returns beginning from the 11th day and ending six months later, relative to the earnings announcement. We calculate returns using daily prices and dividends from Datastream given the concerns in Ince and Porter (2006) with regard to returns estimated from the Return Index (RI) data-item. Following Lee (2011) we drop any day where more than 90% of the shares outstanding are not traded (i.e. have zero return on that day). Furthermore, in order to filter out suspicious stock returns, we follow Chui, Titman and Wei (2010) and set returns that are greater than 100% (-95%) equal to 100% (-95%). Finally, thin trading leading to missing returns may also compromise our statistical inferences, and therefore we calculate trade-to-trade returns (Maynes and Rumsey, 1993). Specifically, trade-to-trade returns are calculated from non-missing price days. For a stock with a missing price, the corresponding portfolio return is added to the next non-missing price day's portfolio return for a trade-to-trade abnormal return calculation.[13] In addition, to reduce the influence of our thin trading adjustment on abnormal

and Kim, 1991). We further exclude forecasts preceding the earnings announcement by more than 200 days to prevent stale forecasts being included in the analysis.

[12] We eliminate firm year observations whose accounting reporting period is less than 340 and more than 380 days (similarly to García Lara, García Osma and Mora, 2005).

[13] An alternative approach is to calculate lumped returns which consist of trade-to-trade returns on non-missing price days and zero on missing price days with no adjustment to the portfolio return when returns are missing, given that this procedure does not allow for missing returns. Using lumped returns, instead of trade to trade, does not alter our conclusions.

returns, we follow Hung et al. (2014) and require firms to be traded for at least 70% of the trading days within our measurement period.

5.3 Insider trading

Information on directors' trading is from the Hemmington Scott Directors' Trading Dataset. In line with prior research in the UK (e.g. Fidrmuc et al., 2006), we define insider transactions as purchases or sales by both executive and non-executive directors, but we allow for a number of different definitions of the directors trading signal. A common definition is the net purchase ratio (e.g. Beneish and Vargus, 2002), and we employ this firm-specific measure of net insider trading, aggregating all directors' trading activity within a period, as follows:

$$NPR = [PURCHASES - SALES]/[PURCHASES+SALES] \qquad (4)$$

where *PURCHASES* is the value of shares purchased by directors and *SALES* is the value of shares sold in the period after the earnings announcement. A positive *NPR* could be the result of directors purchasing more shares or selling fewer shares and *vice versa* for a negative *NPR*. A positive *NPR* indicates net insider buying, whereas a negative *NPR* indicates net insider selling. *NPR* is estimated using only open market purchases and sales of common shares in line with Veenman (2012) . A possible criticism of the *NPR* in equation (4) is that it does not take into account the relative importance of directors' trades in terms of their personal wealth: a trade which represents only a small percentage of the shares already owned by the director is likely to be less informative than a trade with a substantial impact on the directors' wealth. We address this concern by estimating a "weighted-NPR", where the weights applied are estimated as the ratio of the respective trade-size to the shares owned by the director. In the case of a single director trading, this will have no effect on the definition of a buy or sell signal. However, when many directors trade, the weighted-NPR depends on weights attached to the respective trades. We also employ an alternative measure which identifies the direction of the insider trading signal based on the direction of the majority of directors' trading. We refer to this signal as "Net trades", and in this case a buy signal would be defined when more directors are buying shares than directors selling shares, and vice versa for a sell signal. Finally, we acknowledge that in the presence of conflicting transactions (e.g., some directors sell and some buy), the insider trading signal may be ambiguous. In contrast, when all directors trade in the same direction, the trading signal is likely to be strong and clear. Our final definition of a

directors trading signal is based on "Consistent trades", when multiple directors in a given company all trade in the same direction.

We provide summary statistics on the sample of directors' trades both before and after the earnings announcement in Table 2. Each panel reports the value of directors' purchases and sales (which are fewer in number but larger in value), the daily net value of these trades across directors trading in the same firm, and the NPR calculated over the relevant period. We organise the presentation of this data across various windows of insider trading observation around the earnings announcement day (0): Panel A reports the insider trading statistics over the period of 72 days before the earnings announcement to 10 days after it (-72, +10); Panel B captures the period preceding the trading ban (-72, -42) and Panel C covers the trading ban period (-41, -1). In Panel D, we identify insider trading transactions that are disclosed within the first ten days after and including the earnings announcement, which also coincides with the end of the trading ban. Additionally, Panel D presents summary statistics for the four alternative proxies of the insider trading signal employed here: (NPR, weighted-NPR, Net trades and Consistent trades) corresponding to the top and bottom quintiles formed on the basis of the earnings surprise. Note that both NPR and weighted-NPR are scaled to lie between (-1, +1). Figure 2 summarises the information in Table 2 and shows the number of daily insider trading transactions across all firms in our data set around the time of an earnings announcement (day 0), from 72 days before the earnings announcement to 10 days after. The figure confirms the effectiveness of the trading ban starting from approximately 42 (trading) days before the earnings announcement.

TABLE 2 AND FIGURE 2 ABOUT HERE

Figure 2 indicates that the incidence of directors' trading in the period after the earnings announcement is dramatically higher than in the period before the earnings announcement, and motivates our choice of a 10-day post-announcement period to compute our directors trading measures. The figure confirms insiders' reluctance to trade before the announcement and preference to delay their trades as the former may expose them to litigation or reputation costs. In particular, the patterns of directors trading presented on Figure 2 demonstrate that they trade as early as the earnings announcement day and these trades are disclosed to the market in a timely fashion.

5.4 Discretionary accruals

We estimate discretionary accruals in a two-stage procedure. In the first stage we use the Modified Jones (1991) model to predict the level of "non-discretionary" accruals as a function of the growth in revenues and gross property, plant and equipment. Specifically, we run a regression of total accruals for firm *i*, year *t* and sector *j* (two- digit ICB industry classification[14]) on the change in revenues and gross property, plant and equipment where all variables are scaled by the beginning total assets for each year. The second stage predicts the non-discretionary component of accruals using the estimated coefficients from the first stage. Note that in second stage, the influence of the cash sales is also taken into account by introducing the change in receivables, similarly to Dechow, Sloan and Sweeney (1995).[15] The "non-discretionary" part of the accruals then represents an estimate of the expected level of accruals and the remaining component is presumed to include managements' discretion on accruals. Moreover, since performance might also be a determinant of the level of accruals, the estimated discretionary accruals here are also "performance adjusted" in the manner advocated by Kothari, Leone and Wasley (2005) by adding return on assets (ROA) as an additional explanatory variable in the estimation of "non-discretionary" accruals. Since firms do not announce their earnings on the same day or time of the year, the variables used to calculate discretionary accruals are not available for all firms in the same industry-year portfolio. Therefore, the entire distribution of discretionary accruals is typically unknown to the investors at the earnings announcement and, as a result, the hedge portfolio strategies that underlie our investigation cannot be implemented. Following Louis and Sun (2011), we address this issue by estimating the accrual model one year prior to the portfolio formation and then applying the estimated coefficients to the second stage of the estimation process and using the cut-off points from the year before (similar to the quintile ranks of the earnings surprise).

6 Analysis

6.1 Results

Table 3 presents the initial univariate evidence on the post earnings announcement buy-and-hold market adjusted abnormal returns over the six months period (+11, +125) after the

[14] The two digit ICB provides 15 industry classifications where the equivalent SIC leads to 66 industry classifications, excluding missing and financial observations. We require at least 6 observations for each industry-year sub-sample (similarly to García Lara et al., 2005).

[15] The change in receivables is included in order to control for managers' attempts to manipulate earnings through discretionary revenues

earnings announcement. Panel A shows returns corresponding to the top and bottom quintiles of earnings surprises. The spread in returns between the top and bottom quintiles supports the presence of under-reaction to the earnings announcement. The average abnormal returns in the top quintile of earnings surprises are larger (+ 2.3%) than those in the bottom quintile (-1.1%), and this difference (+3.4%) is statistically significant, confirming the presence of the PEAD anomaly in the UK.

TABLE 3 ABOUT HERE

Panel B of Table 3 demonstrates the effect of conditioning these buy-and-hold abnormal returns on contrarian insider trading. In the presence of contrarian insider trading, the average buy and hold abnormal return over six months following the earnings announcement for the observations in the top quintile of the earnings surprise has a smaller magnitude than the corresponding figure for the observations in the bottom quintile. Moreover, the magnitude of the returns in both quintiles is low and not significantly different from zero. Confirming our first hypothesis H1, this finding suggests that in the presence of contrarian trades, the market interprets the earnings surprise as a transitory change in the earnings process and thus, does not capitalise its magnitude into share prices: there is no subsequent market reaction and the PEAD is mitigated. In contrast, the results in Panel C show that when there are confirmatory insider trades, the market infers that there has been a permanent change in the earnings process. Prices continue to move along the direction of the earnings surprise indicating that the market considers that the earnings surprise has information about a permanent change in the earnings process. The PEAD anomaly is particularly pronounced among this set of observations as the return spread between top and bottom earnings surprise quintiles is 7.3%. Further analysis indicates that this result is driven by the effect of insider purchases rather than sales. Being a costly and hence, credible signal of good prospects, confirmatory purchases represent a strong signal that insiders regard the earnings surprise as reflecting a permanent change in the earnings process. Panel D reports the univariate results for earnings announcements with no subsequent directors' trades. In this case the drift is similar to the pooled sample, but is smaller than in Panel C, highlighting the exacerbated response to confirmatory trades accelerates investor learning. Evidence of PEAD in the absence of directors' trading implies that directors' trading can only partly explain the PEAD.

Table 4 reports the multivariate implementation of model (1) and provides evidence of an under-reaction to earning announcements after controlling for risk factors relevant to the

UK stock market. In addition, the regression employed here takes into account the panel structure of the data using firm- clustered standard errors and year fixed effects. Evidence on the PEAD anomaly is shown by the positive and significant coefficient of *RUE;* as explained in Section 4, the coefficient on *RUE* represents the spread in average abnormal returns between observations in the highest and lowest unexpected earnings surprise quintiles. The spread results reported in the first column of Table 4 provide significant evidence of PEAD (0.020; p-value<0.05) even after controlling for size, momentum, book to market and other risk effects.

TABLE 4 ABOUT HERE

The results from testing hypotheses H1 and H2 are reported in the last four columns of Table 4. Consistent with our univariate tests, we find no significant evidence of under-reaction to the earnings surprise in the presence of contrarian insider trading. Specifically, the coefficient on *Ctrar_RUE* denoting the spread in average abnormal returns in the presence of contrarian trading, is -0.039 and statistically insignificant when we define insider transactions based on the net purchase ratio. We report similar results when we use the alternative definitions of the directors' trading signal. These findings support our hypothesis H1 with respect to the role of contrarian trading in mitigating the PEAD. In contrast, confirmatory insider trading conveys information to the market that there has been a permanent change in the earnings process. This is denoted by the magnitude and significance of the *Cfirm_RUE* coefficient across all alterative definitions of the insider trading signal. (e.g. 0.087; p-value<0.01 when defining directors' trading signal based on NPR). In the absence of directors' trading there is still significant evidence of the PEAD as reflected by the value of the coefficient on *NT_RUE* across all definitions of directors' trading signal (e.g. 0.019; p-value<0.05 when defining directors' trading signal based on NPR). Share prices continue to move along the direction of the surprise, but the drift is less pronounced than in the case of confirmatory directors' trade. This would suggest that directors' trades cannot completely explain all of the PEAD, but there may well be other sources of information available to investors' post-earnings announcement enabling them to infer the permanent-transitory nature of the earnings surprise.

To further support our evidence with respect to the information conveyed by contrarian and confirmatory insider trading about the permanent-transitory nature of earnings surprise we test whether the coefficients are statistically significantly different from one another using Wald tests. Collectively, the results indicate that the coefficient of *Cfirm_RUE* is significantly

higher than the coefficient of *NT_RUE* which in turn, is larger than the coefficient of *Ctrar_RUE.* This hierarchy highlights the distinctive effect of insider trading upon the PEAD and is in line with our predictions as illustrated in Figure 1. Overall, these findings confirm the important role for directors' contrarian trading in alleviating the PEAD anomaly while confirmatory insider trading explains, in part, the PEAD.

The proposition advanced in the development of hypotheses H1 and H2 is that the disclosure of informed insider trading provides relevant information to the market that accelerates investors' learning on the transitory-permanent nature of the earnings surprise. In Table 5, we provide further support to our hypotheses by examining the influence of earnings precision on the speed at which investors incorporate the news about the earnings surprise.

TABLE 5 ABOUT HERE

Francis et al. (2007) argue that low earnings precision delays investors' learning and hence, aggravates the under-reaction to earnings announcements. In line with this argument, we find that the PEAD is more pronounced and significant under circumstances of low earnings precision. In the first column of Table 5, we report that the coefficient of RUE_{it} is positive and significant (0.031; p-value <0.01), but the PEAD dissipates as earnings precision increases (denoted by the interaction between PREC and RUE: -0.035; p-value<0.10).

The remaining four columns in Table 5 present the results of testing the two parts of Hypothesis H3 for the four alternative proxies of insider trading signals. In H3 we predict that the insider trading signal initiates a learning process which is distinctive from the learning process underlying the earnings precision. That is, we expect that contrarian directors' trading has a distinct ability to unravel the earnings process even under circumstances where we expect that the PEAD should occur (H3a). The tests reported in Table 5 confirm this hypothesis by means of the small magnitude and insignificant coefficient of *Ctrar_RUE*, when the earnings precision is low. This result is in contrast to the coefficients of *Cfirm_RUE* and *NT_RUE* both of which are significant and large in magnitude. A comparison of the coefficients reported in the "*Low earnings precision*" panel supports this inference.

Analogous to H3a, hypothesis H3b predicts that confirmatory trades will initiate an exacerbated PEAD even under circumstances where the PEAD is not expected to occur. The results reported on Table 5 support this prediction. First, we find that the coefficient of *Cfirm_RUE* is large and significant. The coefficient of *Cfirm_RUE* captures the PEAD

anomaly for those firms with low earnings precision (PREC=0) in the presence of confirmatory insider trading, and its estimated value is 0.065 with a p-value <0.10, in the case of the NPR signal. More importantly, the coefficient of the interaction between *Cfirm_RUE* and *PREC* is positive and insignificant denoting a persistent PEAD, even under circumstances of high earnings precision. Again, the results from a comparison of the coefficients reported in the "*High earnings precision*" panel re-affirm this inference: under high earnings precision, the PEAD is present only when directors trade in a confirmatory direction.

Finally, when directors are not trading, we find that the earnings precision effect dominates, with the absence of insider trading in low precision firms, denoted by *NT_RUE*, producing a coefficient that is positive and significant (0.036; p-value <0.05). High precision earnings mitigate the uncertainty as reflected by the significant negative coefficient of the interaction between *NT_RUE* and *PREC*. The contrast between the results in the absence of insider trading and the results discussed earlier serves to attest to the distinctive effect of insider trading on the PEAD.

6.2 Sensitivity tests

We conduct a series of sensitivity checks to confirm whether our findings are robust to alternative definitions of the key variables. These results are available in an On-line Appendix 3, but we summarise the main findings here. It might be argued that the apparent PEAD anomaly, identified in Table 3 and in the first column of Table 4, may be spurious if it is not economically important, even though it is statistically significant, since it might not be possible to design a trading strategy that implements the apparent anomaly. [16] We have therefore re-estimated the initial multivariate PEAD regressions (first column Table 4) on the significance of the spread between top and bottom quintile portfolios (formed from earnings surprises) using implementable returns following Soares and Stark (2009). We use a "June-strategy" and rank firms each year according to their unexpected earnings at the end of June. Subsequently, we measure returns from the beginning of July and for six months using daily returns as in our

[16] As we discuss in the research design we determine the cut-off points of the quintile ranks of the earnings surprise and earnings precision by the distribution of the earnings surprise and discretionary accruals in the previous year in order to ensure that the portfolio strategies are implementable similar to Louis and Sun (2011).

original tests. The spread on the RUE coefficient remains positive and significant, so the original PEAD is robust to implementable returns; and there is an anomaly to be explained.

In a second robustness test we assess the PEAD over alternative time horizons (2, 3, 4, and 5-months), and we find that the unconditional spread is always significantly positive, with values of 1.3% for the 2-month, 0.9% at the 3-month and 4-month horizons, 2.0% at the 5-month horizon, and increases to 3.4% (as reported in Table 3) at the 6-month horizon. In the presence of contrarian trades, at all horizons this spread is not significantly different from zero. In contrast, conditioned on confirmatory trades, the spread is significantly positive, and the median spread increases with the time horizon. The multivariate regression results for 2-month, 3-month 4-month and 5-month post-earnings announcement time horizons confirm that conditioning on contrarian trades, the PEAD spread evaporates, but is exacerbated in the presence of confirmatory trades. To further confirm that the effect of insider trading on the PEAD is distinct from the initial short term reaction to its disclosure (Veenman, 2012), we delay the starting date of return accumulation. Rather than starting on day (+11), we start the accumulation on day (+21) and we observe the PEAD over the subsequent 5-months period. The unconditional spread is now even wider (+2.4%) and our inference with respect to the effect of insider trading remains unchanged.

Third, we check the sensitivity of our results to the period over which we observe the insiders' signal. Instead of calculating the directors' trading signals over the 10-day period after the earnings announcement, in a third set of tests we calculate the four alternative signals over the period (0, +5) and (0, +17), starting the return accumulation over six months from day +6 and +18 respectively. We find that the unconditional PEAD spread, and the PEAD spread conditioned on confirmatory and contrarian trades are of the same order of magnitude as the reported results in Tables 3 and 4, although with the short (0, +5) directors' trading period, we lose some significance because the numbers of observations with directors' trading is smaller.

Fourth, we exclude 370 observations from 75 companies that report quarterly interim reports after the annual earnings announcements. Fifth, we exclude 439 firms that were listed on AIM, rather than the Main Market on the basis that trading in these firms is likely to be relatively illiquid. Finally, we partition our earning precision measures in terms of quintiles instead of terciles. In all cases the results are consistent with the main findings with respect to the effect of contrarian and confirmatory directors trading on the PEAD.

7 Conclusions

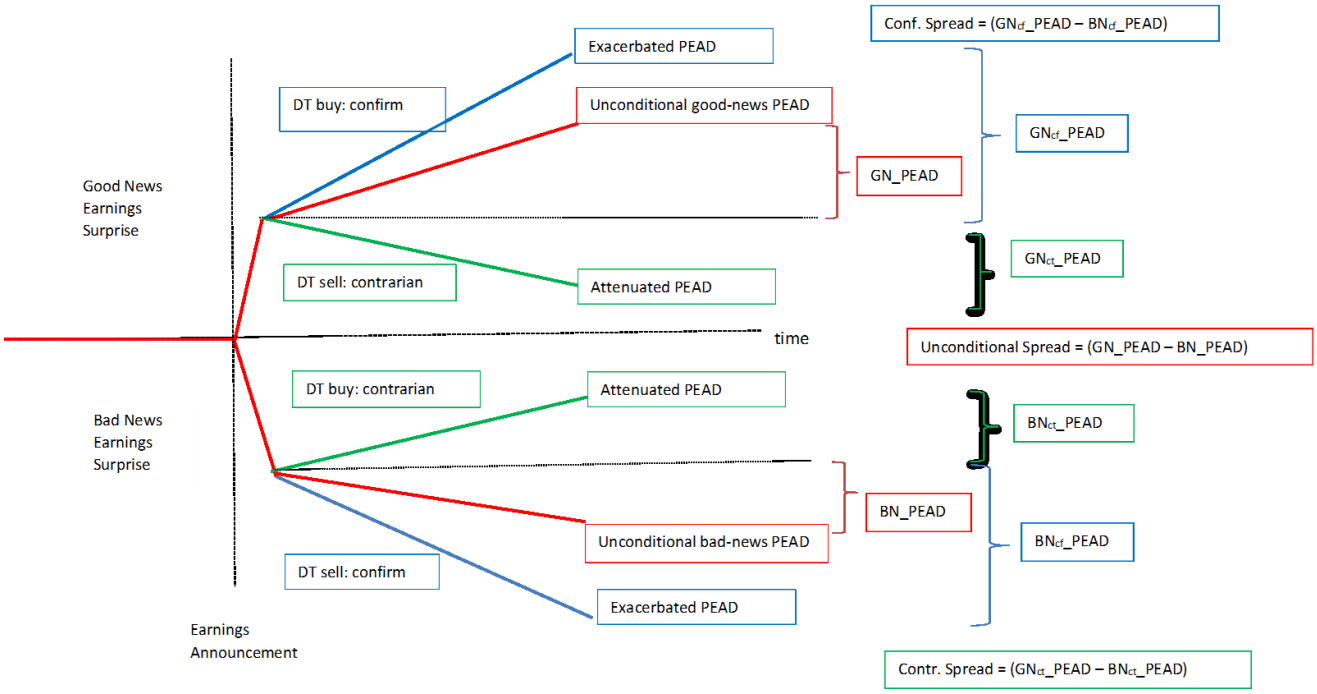
In this paper we have argued that the PEAD is a consequence of investors learning and updating their beliefs as to whether a structural change has occurred in the earnings process. When companies announce unexpectedly high or low earnings, investors must establish the implications of the earnings surprise for future earnings: does the earnings announcement represent a transitory change in profitability or a permanent change in earnings to a new average level? Directors trading immediately after the earnings announcement provide additional information on the transitory or permanent nature of the earnings surprise. Given directors' access to inside information we would expect them to be in an advantageous position to assess the valuation implications of an earnings surprise. If directors sell after good news, or buy after bad news – in other words trade in a contrarian direction to the earnings surprise - this suggests that the director believes that the earnings surprise reflects only a transitory change in the earnings process and therefore, it will not support a further change in the share price along the direction of the earnings surprise. We also examined directors buying after good news and selling after bad news, and such confirmatory trades suggest directors consider the earnings surprise to represent a permanent change in earnings. Nevertheless, we note that in the case of confirmatory trades, investors may have difficulty in assessing the new permanent levels of equilibrium share prices resulting in a stronger drift.

We find that conditioning stock price movements after an earnings announcement on contrarian and confirmatory directors' trades sheds light on the well-documented anomaly, the market under-reaction to earnings announcements, or PEAD. Recognising that the under-reaction represents a delayed response to the earnings surprise, we demonstrate that contrarian directors' trades mitigate the PEAD, and confirmatory trades allow for a continuation of the PEAD as prices to continue to move in the direction of the earnings surprise. Further analysis demonstrates that contrarian trades guide the market to establish that the earnings surprise does not consist a permanent shift in the earnings process even in hard-to-value firms with low earnings precision. On the contrary, confirmatory trades initiate a learning process to establish the shift in the earning process even under circumstances where this is not likely to occur, i.e., under high earnings precision. Taken together these results speak to the particular effect of insider trading on the long-term price discovery.

A caveat to these findings is that insider trading can only in part explain the PEAD. Although our study contributes to the understanding of the PEAD anomaly from a learning

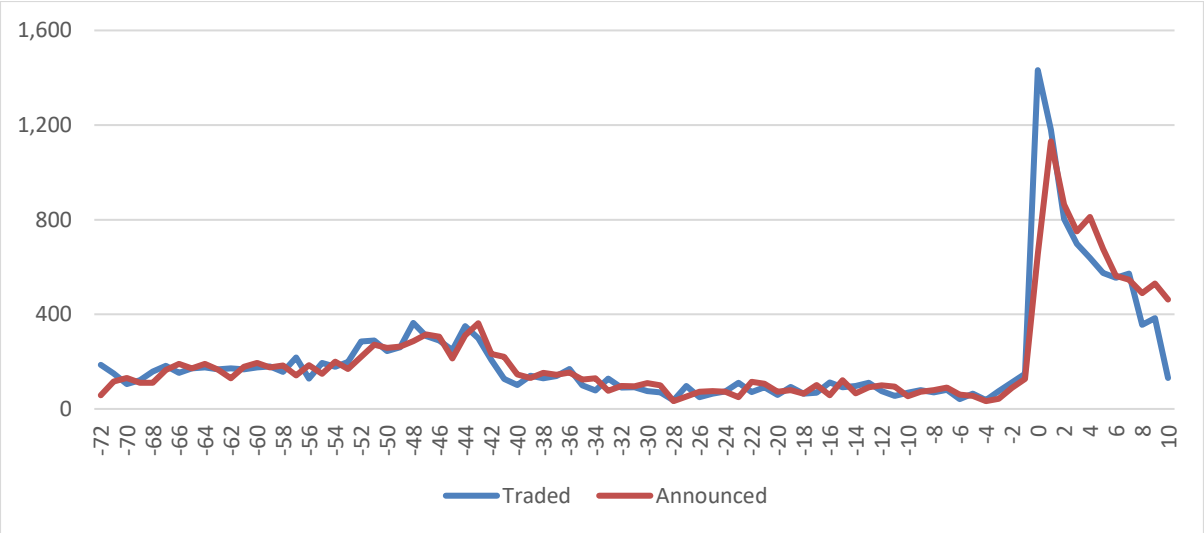
mechanism perspective, further research could identify other sources of information that investors use to update their beliefs on structural changes to the earnings process.

Figure 1: Predicted effects on stock prices of directors' trading after an earnings announcement



Notes: The figure shows predicted stock market responses after the earnings announcement and post-earnings announcement directors' trades, and the effect of conditioning on confirmatory and contrary directors' trades (DT).

Figure 2: Number of directors' trades per day around earnings announcements



Notes: The figure shows the total number of daily directors' trades up to 72 days before an earnings announcement and 10 days after. The trading ban is in place from day -42 to day 0. The blue line denotes days when the directors' trades occur, and the brown line denotes days when the directors' trades are reported to the market.

Table 1: Sample Selection process

19,804	**Initial sample of firm-year observations** The initial sample consists of all publicly listed companies in the UK between 1995 and 2013 with available accounting data. In identifying the firms that have been listed in the UK, we use Datastream's research lists of active (GRP1-6) and dead companies (DEADUK1-7). From these lists we eliminate duplicates, instruments which are not classified as equity, non-primary issues and financial firms (based on ICB industry classification).
(11,824)	Total firm-year observations excluded, of which:
(9,366)	Missing earnings announcements. We require the earnings announcements to be available in Datastream or I\B\E\S. We use the earliest earnings announcement reported in Datastream or I\B\E\S after eliminating earnings announcements announced 200 days after the fiscal year end.
(73)	Missing data needed to estimate unexpected earnings
(2,044)	Missing returns data needed to estimate returns
(7)	Missing accounting data needed to estimate earnings precision
(334)	Outliers removed
7,980	**Final sample: [*firms =1,373*]**

Table 2: Descriptive Statistics Directors' Trading

	Number of trades	Mean	Min (000s)	Q1	Median	Q3	Max (000s)
Panel A: Full Sample period (-72,+10)							
Value shares bought (£)	12,772	44,708	0.001	126	2,750	16,880	69,200
Value shares sold (£)	2,718	743,654	0.031	25,253	117,699	491,643	130,000
Net value traded (£ firm-days)	6,850	-211,712	-130,0000	130	3,955	25,475	54,800
NPR (firm level)	3,501	0.44	-1.00	-0.58	1.00	1.00	1.00
Panel B: Pre-ban period (-72,-42)							
Value shares bought (£)	4,763	63,316	0.001	126	2,998	15,795	69,200
Value shares sold (£)	736	163,644	0.003	3,860	20,000	109,491	6,500
Net value traded (£ firm-days)	2,671	-60,737	-34,000	248	5,250	24,350	54,800
NPR (firm level)	1,839	0.61	-1.00	1.00	1.00	1.00	1.00
Panel C: Ban period (-41,-1)							
Value shares bought (£)	3,297	13,502	0.002	123	127	1,015	14,000
Value shares sold (£)	172	382,980	0.031	14,775	63,157	478,258	6,150,000
Net value traded (£ firm-days)	1,228	-17,388	-6,560	244	476	3,323	14,000
NPR (firm level)	711	0.78	-1.00	1.00	1.00	1.00	1.00
Panel D: Post-EA period (0, +10)							
Value shares bought (£)	4,712	47,734	0.003	1,740	10,000	30,700	20,100
Value shares sold (£)	1,810	824,074	0.10	31,338	137,587	502,400	130,000
Net value traded (£ firm-days)	2,963	-427,489	-130,000	-10,889	9,026	40,026	22,200
NPR (firm level): All	2,228	0.39	-1.00	-0.99	1.00	1.00	1.00
NPR: UE1 Quintile	415	0.60	-1.00	1.00	1.00	1.00	1.00
NPR: UE5 Quintile	422	0.42	-1.00	-0.96	1.00	1.00	1.00
Weighted NPR: UE1 Quintile	415	0.60	1.00	1.00	1.00	1.00	1.00
Weighted NPR: UE5 Quintile	422	0.42	1.00	1.00	1.00	1.00	1.00
Net trades: UE1 Quintile	240	2.66	-8.00	2.00	3.00	4.00	17.00
Net trades: UE5 Quintile	245	1.93	-14.00	2.00	2.00	4.00	14.00
Consistent trades: UE1 Quintile	204	2.85	-6.00	2.00	3.00	4.00	15.00
Consistent trades: UE5 Quintile	204	2.14	-6.00	2.00	2.00	4.00	10.00

Notes: The table provides descriptive statistics on the sample of directors' trades (by executive and non-executive board members) in their own company shares across 1,373 firms over the period 1995-2013 in the 92-day period (-72,+10) around the annual earnings announcement. Panel A documents directors' trading statistics for the full sample period; Panel B for the period (-72, -42) before the trading ban; Panel C for the period (-41, -1) during the trading ban; Panel D for the period (0, +10) after the earnings announcement which is made at the start of day 0. The first and second rows of each panel shows the distribution of the value of shares purchased and sold; the third row shows the distribution of the net daily shares traded across directors in the same firm (positive for buys, and negative for sales) by value of shares traded; and the fourth row shows the distribution of the NPR calculated at the firm level for the relevant sample period by value of transactions. NPR is defined as the net value of shares traded scaled by the value of shares traded, and hence lies between (-1, +1). The fifth and sixth rows of Panel D show the distribution of NPR for the bottom and top quintile portfolios formed by earnings surprise. The seventh and eighth rows of Panel D show the distribution of Weighted NPR for the UE5 and UE1 quintile portfolios, where weighted NPR accommodates the effect of directors' shareholding wealth. The ninth and tenth rows of Panel D show the distribution of Net trades for bottom and top quintile portfolios, where Net trades is defined as the (unscaled) difference between the number of buy and sell signals. The last two rows of Panel D show the distribution of Consistent trades for bottom and top quintile portfolios, defined as the (unscaled) number of trade signals by multiple directors in the same direction.

Table 3: Spread returns

Panel A: Spread returns for the pooled sample			
	UE 1	UE 5	UE 5 - UE 1
N	1591	1679	
Mean	-0.011*	0.023***	0.034***
Median	-0.001	0.019***	0.021***
Panel B: Spread returns in the presence of contrarian insider trading			
	UE 1	UE 5	UE 5 - UE 1
N	329	122	
Mean	0.011	-0.004	-0.014
Median	0.033	-0.028	-0.061
Panel C: Spread returns in the presence of confirmatory insider trading			
	UE 1	UE 5	UE 5 - UE 1
N	82	299	
Mean	-0.030	0.043***	0.073**
Median	-0.023	0.048***	0.071***
Panel D: Spread returns in the absence of insider trading			
	UE 1	UE 5	UE 5 - UE 1
N	1180	1258	
Mean	-0.016**	0.020***	0.036***
Median	-0.004	0.010**	0.013**

*, ** and *** denote significance at the 10%, 5% and 1% respectively.

Notes: Table reports univariate six-month buy-and-hold portfolio returns after earnings announcement for quintiles of high earnings surprises (UE 5) and low earnings surprises (UE 1), and spread portfolio between these two portfolios (UE 5 – UE 1). Panel A reports buy-and-hold returns (BHARs) for the full sample. Panel B reports BHARs for sample of contrarian insider trades, and Panel C reports BHARs for sample of confirmatory insider trades. Panel D reports BHARs for a sample of firm announcements after which there are no directors' trades. In all cases the directors' trading signal is based on the net purchases ratio, NPR.

Table 4: PEAD and the presence of contrarian and confirmatory insider trading with alternative insider trading signals.

VARIABLES	Base model	NPR	Weighted NPR	Net trades	Consistent trades
Constant	-0.129***	-0.131***	-0.131***	-0.130***	-0.131***
	(-8.04)	(-8.14)	(-8.14)	(-7.99)	(-8.00)
RUE	0.020**				
	(2.03)				
Ctrar_RUE		-0.039	-0.038	-0.028	-0.014
		(-1.48)	(-1.43)	(-0.70)	(-0.30)
Cfirm_RUE		0.087***	0.086***	0.109**	0.108**
		(2.82)	(2.78)	(2.57)	(2.11)
NT_RUE		0.019*	0.019*	0.019*	0.019*
		(1.68)	(1.70)	(1.68)	(1.68)
Ctrar		-0.009	-0.007	0.015	0.026
		(-0.62)	(-0.51)	(0.72)	(1.11)
Cfirm		-0.005	-0.006	-0.021	-0.021
		(-0.32)	(-0.35)	(-0.99)	(-0.81)
Q5MM	0.088***	0.089***	0.089***	0.087***	0.086***
	(8.70)	(8.84)	(8.83)	(8.53)	(8.35)
Q5BM	0.024**	0.023**	0.023**	0.023**	0.025**
	(2.11)	(2.03)	(2.04)	(1.98)	(2.09)
Q5MV	0.053***	0.053***	0.053***	0.053***	0.054***
	(4.23)	(4.23)	(4.23)	(4.14)	(4.15)
Q5LEV	0.033***	0.032***	0.032***	0.035***	0.035***
	(3.09)	(2.99)	(2.99)	(3.14)	(3.15)
Q5RD	-0.009	-0.010	-0.010	-0.009	-0.010
	(-1.19)	(-1.29)	(-1.29)	(-1.19)	(-1.24)
Q5SP	-0.065***	-0.064***	-0.064***	-0.064***	-0.064***
	(-5.34)	(-5.25)	(-5.25)	(-5.17)	(-5.12)
Q5CFO	0.084***	0.084***	0.084***	0.085***	0.085***
	(8.38)	(8.41)	(8.41)	(8.49)	(8.51)
Q5CC	-0.007	-0.007	-0.007	-0.007	-0.008
	(-0.64)	(-0.63)	(-0.63)	(-0.64)	(-0.67)
Year fixed effects	Yes	Yes	Yes	Yes	Yes
N	7,980	7,980	7,980	7,628	7,550
Adj R-squared	0.0726	0.0734	0.0733	0.0724	0.0710
F test	21.08	19.49	19.47	18.94	18.53
Wald tests testing the equality of coefficients					
		Diff	Diff	Diff	Diff
Cfirm_RUE -Ctrar_RUE		0.127***	0.124***	0.138**	0.121*
		(3.16)	(3.09)	(2.43)	(1.84)
Cfirm_RUE- NT_RUE		0.068**	0.067**	0.090**	0.088*
		(2.07)	(2.02)	(2.05)	(1.70)
NT_RUE-Ctrar_RUE		0.058**	0.057**	0.047	0.033
		(2.01)	(1.97)	(1.12)	(0.69)

Notes: The first column of the table reports the results from estimating equation (1) and the remaining four columns report the results from estimating (2) under alternative definitions of the directors' trading signal: the second column presents the results when directors trading signal is based on the net purchase ratio (NPR); the third column when directors trading signal based on the weighted net purchase ratio, where weights depend on

directors' shareholding wealth (weighted NPR); the fourth column when directors trading signal defined by majority of the directors are trading in the same direction (Net trades); and last column when directors trading signal depends on multiple directors all trading in the same direction (Consistent trades). UE is quintile rank of earnings surprise where unexpected earnings is calculated as the difference between the I/B/E/S actual reported earnings and the single most recent forecast deflated by the stock price; RUE stands for rescaled unexpected earnings quintiles, and equals -0.5 if the firms belongs to the lowest quintile of UE, 0.5 if a firm belongs to top quintile of UE and zero otherwise; *Ctrar*_RUE equals to RUE in the presence of informed insider trading, and zero otherwise; *Cfirm*_RUE equals to RUE in the presence of non-informed insider trading, and zero otherwise; NT_RUE equals to RUE when directors abstain from trading. Risk controls included: Q5MM, quintile rank of momentum measured as the buy-and-hold market adjusted returns over the 6 months up to the earnings announcement; QBM, quintile rank of the book to market ratio; QMV, quintile rank of the market value of the company measured at the fiscal year end for each company; Q5LEV, quintile rank of leverage; Q5RD, quintile rank of the ratio of research and development to market value; Q5SP, quintile rank of the natural logarithm of the share price measured at start of the return accumulation period; Q5CFO, quintile rank of operating cash flows divided by total assets, and Q5CC, quintile rank of capital expenditures divided by market value. Dependent variable is buy-and-hold abnormal return in excess of market return. Terms in brackets are t-statistics, computed from standard errors clustered at the firm level, and where *, ** and *** denote significance at the 10%, 5% and 1% respectively.

Table 5: PEAD and the presence of contrarian and confirmatory insider trading: The impact of earnings signal precision.

VARIABLES	Base model	NPR	Weighted NPR	Net trades	Consistent trades
Constant	-0.130***	-0.131***	-0.131***	-0.130***	-0.131***
	(-8.00)	(-8.09)	(-8.09)	(-7.93)	(-7.96)
RUE	0.031***				
	(2.59)				
RUE*PREC	-0.035*				
	(-1.82)				
Ctrar_RUE		-0.030	-0.030	-0.030	-0.004
		(-0.92)	(-0.93)	(-0.62)	(-0.07)
Ctrar_RUE*PREC		-0.030	-0.024	0.005	-0.027
		(-0.59)	(-0.48)	(0.07)	(-0.39)
Cfirm_RUE		0.065*	0.066*	0.094*	0.071
		(1.70)	(1.72)	(1.77)	(1.11)
Cfirm_RUE*PREC		0.064	0.059	0.039	0.087
		(1.25)	(1.15)	(0.60)	(1.24)
NT_RUE		0.036***	0.036***	0.036***	0.036***
		(2.58)	(2.60)	(2.59)	(2.60)
NT_RUE*PREC		-0.054**	-0.054**	-0.055**	-0.055**
		(-2.28)	(-2.30)	(-2.31)	(-2.31)
PREC	-0.000	-0.002	-0.002	-0.001	-0.001
	(-0.08)	(-0.29)	(-0.27)	(-0.22)	(-0.10)
Ctrar		-0.009	-0.007	0.015	0.026
		(-0.64)	(-0.53)	(0.73)	(1.11)
Cfirm		-0.005	-0.006	-0.020	-0.019
		(-0.32)	(-0.36)	(-0.96)	(-0.72)
Risk controls	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
N	7,980	7,980	7,980	7,628	7,550
Adj R-squared	0.0728	0.0738	0.0737	0.0727	0.0714
F test	19.76	17.53	17.49	16.93	16.60
Wald tests testing the equality of coefficients					
		Diff	Diff	Diff	Diff
Low earnings precision					
Cfirm_RUE -Ctrar_RUE		0.095*	0.096*	0.123*	0.075
		(1.85)	(1.87)	(1.73)	(0.88)
Cfirm_RUE- NT_RUE		0.030	0.030	0.057	0.035
		(0.73)	(0.74)	(1.07)	(0.54)
NT_RUE- Ctrar_RUE		0.066*	0.066*	0.066	0.040
		(1.83)	(1.85)	(1.30)	(0.70)
High earnings precision					
Cfirm_RUE -Ctrar_RUE		0.189***	0.180***	0.158**	0.189**
		(3.32)	(3.13)	(2.12)	(2.36)
Cfirm_RUE- NT_RUE		0.148***	0.143***	0.151***	0.176***
		(3.23)	(3.10)	(2.65)	(2.86)
NT_RUE- Ctrar_RUE		0.041	0.036	0.006	0.013
		(0.91)	(0.80)	(0.11)	(0.20)

Notes The first column of the table reports the results from estimating equation (3) before taking into account directors' trades; the remaining four columns report the results from estimating (3) including directors' trading variables. PREC takes value of 1 if a firm belongs to the bottom tercile of the magnitude of discretionary accruals, and 0 otherwise. The remaining variables and risk controls are explained in the footnote to Table 4. Terms in brackets are t-statistics, computed from standard errors clustered at the firm level, and where *, ** and *** denote significance at the 10%, 5% and 1% respectively.

Appendix 1: Illustration of learning and a delayed response to earnings information

We consider a simple example to illustrate how investors updating their beliefs about a shock to the earnings process, can explain the documented PEAD. The purpose of this example is to show that with a structural change and parameter uncertainty there will be a delayed response to an earnings announcement, as Bayesian investors update on other relevant pieces of information associated with the structural change. There will be a pattern in stock prices following the structural change.

Suppose earnings (e_t) are generated by a uniform distribution $U(.)$, with support $(0, W_0)$. The present value model, with an earnings announcement imminent, would price this earnings stream as $p_{t-1} = 0.5W_0(1 + \delta)$, where δ is the appropriate discount factor. Realised earnings are then announced, and prices jump to $p_t = e_t + 0.5\delta W_0$. At some point after the announcement the price will go ex-dividend, and the stock price will revert to its long-run expected value $(=0.5\delta W_0)$.

Suppose the announced realised earnings are above the upper support of the original uniform distribution: $e_t > W_0$. This event represents a structural change: the earnings process is still generated by a uniform distribution $U(0, W)$, but the distribution of the earnings process has changed, with parameter uncertainty about the new upper limit W. We assume that investors update their beliefs about the unknown parameter W according to Bayesian rules. Following De Groot (1970) Section 9.7 Theorem 1, a conjugate prior for the likelihood function being a uniform distribution is the Pareto distribution with parameters (w_0, α), meaning that the posterior distribution for W after observing a single piece of sample information x_1 from the uniform distribution, is also Pareto with parameters (w_0', α') where $w_0' = max(w_0, x_1)$ and $\alpha' = \alpha + 1$. In the Pareto distribution w_0 is the minimum possible value of W and α is a positive parameter that reflects the shape of the distribution, and reflects the range of possible values of W above the scale parameter w_0. Over time, as more sample information is accumulated, the scale parameter is updated in the posterior distribution to mimic any higher realised values, and over time the shape parameter in the posterior distribution gets larger and the range of upside values above the scale parameter is reduced.

Figure 1 illustrates the initial uniform distribution $U(0, W_0)$, and the post-structural change uniform distribution $U(0, W)$, with the prior beliefs represented by a Pareto distribution of the unknown parameter W. The mean and variance of the Pareto distribution is given by

$$E(W) = \frac{\alpha w_0}{\alpha - 1} \; and \; Var(W) = \frac{\alpha w_0^2}{(\alpha - 1)^2(\alpha - 2)}$$

Which represent the prior beliefs about W. Given the sample information x_1, posterior mean and variance is:

$$E(W|x_1) = \frac{(\alpha + 1)w_0'}{\alpha} \; and \; Var(W|x_1) = \frac{(\alpha + 1)w_0'^2}{\alpha^2(\alpha - 1)}$$

A reasonable candidate for the prior value of w_0 is the realised earnings announcement e_t, and so α represents the strength in the beliefs that e_t is the upper support of the new distribution, or whether the upper support is even higher.

Prices at date *t* (the earnings announcement): Following the unexpected earnings $e_t > W_0$, prices will jump to $p_t = w_0\left(1 + 0.5\delta\frac{\alpha}{\alpha-1}\right)$ which is based on the prior for the Pareto distribution, and is unambiguously higher than in the case of no structural change. Subsequent movements in prices after the earnings announcement depends on any additional sample information provided by whether there is trading by informed insiders or not. The piece of sample information that investors observe is whether a director trades on the day after the earnings announcement, or does not trade. Directors know the true value of *W*, and hence know the true fundamental price $p_t^f = (w_0 + 0.5\delta W)$, which differs from the market price depending on whether $W \geq \frac{\alpha w_0}{\alpha-1}$ investors believe that directors will buy shares if the stock price is $p_t < p_t^f$, and not trade if $p_t = p_t^f$.

So if directors buy shares, investors infer that $W>w_0$ (since $\frac{\alpha}{\alpha-1} > 1$), which constitutes the piece of sample information, and $w_0' = max\ (w_0, I: x_1 > w_0)$ and $\alpha' = \alpha+1$. A simple price adjustment rule is that if investors observe $x_1>w_0$ they set $w_0'=w_0+1$.[17]

Prices at date *t+1*: In which case prices become: $p_{t+1}|\ (I: x_1 > w_0) = w_0 + 0.5\delta\frac{(\alpha+1)(w_0+1)}{\alpha}$ $> p_t$ if $\alpha>\sqrt{(w_0+1)}$. So that following the directors' trade, prices may rise or fall depending on parameter values. For example, prices would rise if $\alpha=w_0=2$, or $\alpha=4,\ w_0=8$. In these cases, prices will rise after the market observes directors' confirmatory trading, and there will be PEAD.

On the other hand if directors do not trade on the day after the earnings announcement, investors infer that $W<w_0$, and $w_0' = max\ (w_0, I: x_1<w_0)$, $\alpha' = \alpha+1$, and prices unambiguously decline: $p_{t+1}|\ (I: x_1 < w_0) = w_0\left(1 + 0.5\delta\frac{(\alpha+1)}{\alpha}\right)$.

For some parameter values prices will fall in both cases, irrespective of the sample information because the learning effect induces an increase in the posterior precision of the unknown parameter W, (Veronesi, 1999). The price fall is always greater in the case of directors not trading. That is, the price following a directors' trade is always higher than the price with no directors' trade: $p_{t+1}|(\ I: x_1 > w_0) > p_{t+1}|(I: x_1 < w_0)$.

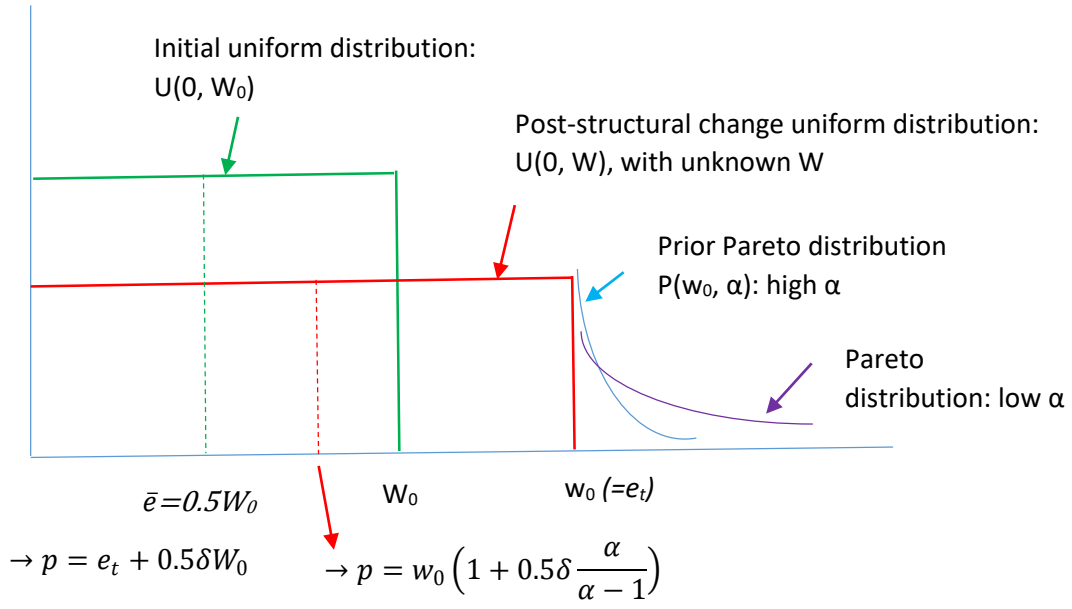
Prices at date *t+2*: Now we progress into the second day after the earnings announcement, and investors will again observe whether directors trade or not. Investors have new priors given by the posterior Pareto distribution from the previous time period with parameters (w_0', α'). Investors will again update their beliefs from the trading behaviour of directors in period t+2 (x_2). If there are no trades from directors, prices fall again to: $p_{t+2}|\ (I: x_2 < w_0) = w_0\left(1 + 0.5\delta\frac{(\alpha+2)}{(\alpha+1)}\right)$; but if directors trade, investors again infer that the fundamental price is

[17] There may be faster updating rules for prices depending upon the model that investors believe directors are following to trade strategically.

above the current market price, and will update their beliefs accordingly, and prices become: $p_{t+2}|(I: x_2 > w_0) = w_0' + 0.5\delta \frac{(\alpha+2)(w_0+2)}{(\alpha+1)}$, with a sufficient condition for being greater than p_{t+1} is the same conditions as previously, so that we observe a PEAD. This process will continue until market prices converge to fundamental prices, which is when directors cease trading.

This example illustrates how learning about a structural change in the context of a shock to earnings and subsequent directors' trading leads to a pattern of stock prices that with the benefit of hindsight may look predictable, but as Lewellen and Shanken (2002) observe, no Bayesian investor would be able to take advantage of this apparent predictable pattern in prices.

Figure A1: Initial and post-structural change uniform distributions for earnings process, along with prior Pareto distribution



The diagram illustrates the shift in the uniform distribution, and the Pareto prior for the unknown W. Note that the subsequent posterior distributions (which depend on the sample realisations) are not represented in this figure.

Appendix 2: Variable definitions

VARIABLE	DEFINITION	SOURCE
BHAR[a]	Buy-and-hold market adjusted abnormal return measured from +11 to +136 days relative to the earnings announcement calculated from trade to trade daily returns. For a stock not traded on a given day, the corresponding market return is added to the next non-missing price day's index return.	Datastream: Price (P), Dividend (DDE), Market return (FTALLSH)
UE	Quintile rank of unexpected earnings. Unexpected earnings are defined as the difference between actual EPS and forecasted EPS scaled by lag price. Quintilecut-off points of the earnings surprise are based on the distribution of the preceding year's surprises.	IBES: forecasted EPS IBES: actual EPS Datastream: Prices (P)
RUE	Rescaled quintile rank of unexpected earnings, which takes the value "-0.5" when an observation belongs to the bottom quintile rank of earnings surprise and "0.5" when an observation belongs to the top quintile rank of earnings surprise. RUE is equal to zero for the intermediate quintiles.	IBES: forecasted EPS IBES: actual EPS Datastream: Prices (P)
Q5MM	Quintile rank of momentum measured as the buy and hold market adjusted returns over the 6 months up to the earnings announcement.	Datastream: Price (P), Dividend (DDE), Market return (FTALLSH)
Q5BM	Quintile rank of firm book-to-market.	Worldscope: Common equity: (WC03501), Market Capitalisation (WC08001)
Q5MV	Quintile rank of firm size measured as the market value of the company measured at the fiscal year end.	Worldscope: Market Capitalisation (WC08001)
Q5LEV	Quintile rank of leverage measured as total debt divided by the market value of the company measured at the fiscal year end.	Worldscope: Total Debt: (WC03255), Market Capitalisation (WC08001)
Q5RD	Quintile rank of the ratio of research and development expenses to the market value of the company measured at the fiscal year end.	Worldscope: R&D expense: (WC01201), Market Capitalisation: (WC08001)
Q5SP	Quintile rank of the natural logarithm of the share price measured at the start of the return accumulation period	Datastream: Price (P),
Q5CFO	Quintile rank of operating cash flows divided by total assets.	Worldscoppe: Total Funds From Operations (WC04201), Other Funds From Operations (WC04831), Total assets (WC02999)
Q5CC	Quintile rank of capital expenditures divided by the market value	Worldscope: Capital Expenditure (WC04601), Market Capitalisation (WC08001)
Ctrar	Dummy variable which equals 1 if the directors' trading signal indicates trading in the opposite direction to the earnings surprise and zero otherwise	Hemscott: Directors trades:
Cfirm	Dummy variable which equals 1 if the directors' trading signal indicates trading in the same direction of the earnings surprise and zero otherwise.	Hemscott: Directors trades:
Ctrar_RUE	Equals to RUE when directors' trading signal indicates trading in the opposite direction of the earnings surprise (when Ctrar equals to 1) and zero otherwise.	IBES: forecasted EPS IBES: actual EPS Datastream: Prices (P)
Cfirm_RUE	Equals to RUE when directors' trading signal indicates trading in the same direction of the earnings surprise (when Cfirm equals to 1) and zero otherwise.	IBES: forecasted EPS IBES: actual EPS Datastream: Prices (P)
NT_RUE	Equals to RUE when the directors' trading signal indicates no directors' trading, and zero otherwise.	IBES: forecasted EPS IBES: actual EPS

		Datastream: Prices (P)
PREC	Earnings precision variable equals to 1 if a firm's earnings are precise and zero otherwise. We define earnings precision based on the magnitude of total discretionary accruals. Firms belonging in the bottom tercile rank of the magnitude of total discretionary accruals have low levels of discretionary accruals and are deemed to report more precise earnings. The cut-off points of the tercile ranks are determined by the distribution of the magnitude of discretionary accruals at the year before. Discretionary accruals are estimated based on the modified Jones (1991) model adjusted for performance.	Worldscope: Income Before Extra Items: WC04001 Total Funds From Operations (WC04201), Other Funds From Operations (WC04831), Sales (WC01001), Total assets (WC02999), Receivables (WC02051), Gross Property, Plant and Equipment (WC02301)

[a] variable trimmed at 2% at the top and bottom of its distribution

References

Abarbanell, J. S. and V. L. Bernard (1992). "Tests of analysts' overreaction/underreaction to earnings information as an explanation for anomalous stock price behavior." *The Journal of Finance*, **47**(3): 1181-1207.

Acemoglu, D., M. A. Dahleh, I. Lobel and A. Ozdaglar (2011). "Bayesian learning in social networks." *Review of Economic Studies*, **78**(4): 1201-1236.

Ali, A., A. Klein and J. Rosenfeld (1992). "Analysts' use of information about permanent and transitory earnings components in forecasting annual EPS." *Accounting Review*: 183-198.

Ayers, B. C., O. Z. Li and P. E. Yeung (2011). "Investor trading and the post-earnings-announcement drift." *The Accounting Review*, **86**(2): 385-416.

Badertscher, B. A., S. P. Hribar and N. T. Jenkins (2011). "Informed trading and the market reaction to accounting restatements." *Accounting Review*, **86**(5): 1519-1547.

Bagnoli, M. and S. G. Watts (2007). "Financial reporting and supplemental voluntary disclosures." *Journal of Accounting Research*, **45**(5): 885-913.

Bartov, E., D. Givoly and C. Hayn (2002). "The rewards to meeting or beating earnings expectations." *Journal of Accounting and Economics*, **33**(2): 173-204.

Bartov, E., S. Radhakrishnan and I. Krinsky (2000). "Investor sophistication and patterns in stock returns after earnings announcements." *The Accounting Review*, **75**(1): 43-63.

Beneish, M. D. and M. E. Vargus (2002). "Insider trading, earnings quality, and accrual mispricing." *Accounting Review*, **77**: 755-791.

Bernard, V. L. and J. K. Thomas (1989). "Post-earnings-announcement drift: delayed price response or risk premium?" *Journal of Accounting Research*, **27**: 1-36.

Bernard, V. L. and J. K. Thomas (1990). "Evidence that stock prices do not fully reflect the implications of current earnings for future earnings." *Journal of Accounting and Economics*, **13**(4): 305-340.

Bhattacharya, N., H. Desai and K. Venkataraman (2013). "Does earnings quality affect information asymmetry? Evidence from trading costs." *Contemporary Accounting Research*, **30**(2): 482-516.

Brav, A. and J. B. Heaton (2002). "Competing theories of financial anomalies." *Review of Financial Studies*, **15**(2): 575-606.

Brennan, M. J. and Y. Xia (2001). "Stock price volatility and equity premium." *Journal of monetary Economics*, **47**(2): 249-283.

Brown, L. D. and K.-J. Kim (1991). "Timely aggregate analyst forecasts as better proxies for market earnings expectations." *Journal of Accounting Research*, **29**(2): 382-385.

Bulkley, G. and P. Giordani (2011). "Structural breaks, parameter uncertainty, and term structure puzzles." *Journal of Financial Economics*, **102**(1): 222-232.

Bulkley, G. and I. Tonks (1989). "Are UK stock prices excessively volatile? Trading rules and variance bound tests." *Economic Journal*, **99**(398): 1083-1098.

Choi, L., L. Faurel and S. A. Hillegeist (2017). "Insider trading and post-earnings announcement drift." *SSRN: http://dx.doi.org/10.2139/ssrn.2801411*.

Chordia, T. and L. Shivakumar (2005). "Inflation illusion and post-earnings-announcement drift." *Journal of Accounting Research*, **43**(4): 521-556.

Chui, A. C., S. Titman and K. J. Wei (2010). "Individualism and momentum around the world." *The Journal of Finance*, **65**(1): 361-392.

David, A. (1997). "Fluctuating confidence in stock markets: Implications for returns and volatility." *Journal of Financial and Quantitative Analysis*, **32**(04): 427-462.

Dechow, P. M. and I. D. Dichev (2002). "The quality of accruals and earnings: the role of accrual estimation errors." *The Accounting Review*, **77**(s-1): 35-59.

Dechow, P. M., R. G. Sloan and A. P. Sweeney (1995). "Detecting earnings management." *The Accounting Review*, **70**(2): 193-225.
Fidrmuc, J. P., M. Goergen and L. U. C. Renneboog (2006). "Insider trading, news releases, and ownership concentration." *Journal of Finance*, **61**: 2931-2973.
Francis, J., R. Lafond, P. Olsson and K. Schipper (2007). "Information uncertainty and post-earnings-announcement-drift." *Journal of Business Finance & Accounting*, **34**(3-4): 403-433.
Freeman, R. N. and S. Y. Tse (1992). "A nonlinear model of security price responses to unexpected earnings." *Journal of Accounting Research*: 185-209.
García Lara, J. M., B. García Osma and A. Mora (2005). "The effect of earnings management on the asymmetric timeliness of earnings." *Journal of Business Finance & Accounting*, **32**(3-4): 691-726.
Hillier, D. and A. P. Marshall (2002). "Are trading bans effective? Exchange regulation and corporate insider transactions around earnings announcements." *Journal of Corporate Finance*, **8**: 393.
Hirshleifer, D., S. S. Lim and S. H. Teoh (2009). "Driven to distraction: extraneous events and underreaction to earnings news." *The Journal of Finance*, **64**(5): 2289-2325.
Hirshleifer, D. A., J. N. Myers, L. A. Myers and S. H. Teoh (2008). "Do individual investors cause post-earnings announcement drift? Direct evidence from personal trades." *The Accounting Review*, **83**(6): 1521-1550.
Hung, M., X. Li and S. Wang (2014). "Post-earnings-announcement drift in global markets: Evidence from an information shock." *Review of Financial Studies*.
Ince, O. S. and R. B. Porter (2006). "Individual equity return data from Thomson Datastream: handle with care!" *Journal of Financial Research*, **29**(4): 463-479.
Jiang, W., N. Soares and A. W. Stark (2016). "Loss persistence and returns in the UK." *Accounting and Business Research*, **46**(3): 221-242.
Jones, J. J. (1991). "Earnings management during import relief investigations." *Journal of Accounting Research*, **29**(2): 193-228.
Kolasinski, A. and X. Li (2010). "Are corporate managers savvy about their stock price? Evidence from insider trading after earnings announcements." *Journal of Accounting and Public Policy*, **29**(1): 27-44.
Korczak, A., P. Korczak and M. Lasfer (2010). "To trade or not to trade: the strategic trading of insiders around news announcements." *Journal of Business Finance and Accounting*, **37**(3-4): 369-407.
Kothari, S. P. (2001). "Capital markets research in accounting." *Journal of Accounting and Economics*, **31**(1–3): 105-231.
Kothari, S. P., A. J. Leone and C. E. Wasley (2005). "Performance matched discretionary accrual measures." *Journal of Accounting and Economics*, **39**(1): 163-197.
Lakonishok, J. and I. Lee (2001). "Are insider trades informative?" *Review of Financial Studies*, **14**(1): 79-111.
Lee, K.-H. (2011). "The world price of liquidity risk." *Journal of Financial Economics*, **99**(1): 136-161.
Lee, Y. J. (2012). "The effect of quarterly report readability on information efficiency of stock prices." *Contemporary Accounting Research*, **29**(4): 1137-1170.
Lewellen, J. and J. Shanken (2002). "Learning, asset-pricing tests, and market efficiency." *Journal of Finance*, **57**(3): 1113-1145.
Liang, L. (2003). "Post-earnings announcement drift and market participants' information processing biases." *Review of Accounting Studies*, **8**(2-3): 321-345.
Liu, W., N. Strong and X. Xu (2003). "Post–earnings–announcement Drift in the UK." *European Financial Management*, **9**(1): 89-116.

Louis, H. and A. X. Sun (2011). "Earnings management and the post-earnings announcement drift." *Financial Management*, **40**(3): 591-621.
Manne, G. H. (1966). *Insider trading and the stock market*. New York, The Free Press.
Maynes, E. and J. Rumsey (1993). "Conducting event studies with thinly traded stocks." *Journal of Banking & Finance*, **17**(1): 145-157.
Mendenhall, Richard R. (2004). "Arbitrage risk and post-earnings-announcement drift." *The Journal of Business*, **77**(4): 875-894.
Milian, J. A. (2015). "Unsophisticated arbitrageurs and market efficiency: overreacting to a history of underreaction?" *Journal of Accounting Research*, **53**(1): 175-220.
Narayanamoorthy, G. (2006). "Conservatism and cross-sectional variation in the post–earnings announcement drift." *Journal of Accounting Research*, **44**(4): 763-789.
Ng, J., T. O. Rusticus and R. S. Verdi (2008). "Implications of transaction costs for the post–earnings announcement drift." *Journal of Accounting Research*, **46**(3): 661-696.
Pástor, Ľ. and P. Veronesi (2003). "Stock valuation and learning about profitability." *Journal of Finance*, **58**(5): 1749-1790.
Piotroski, J. D. and D. T. Roulstone (2007). "Evidence on the non-linear relation between insider trading decision and future earnings." *Journal of Law, Economics & Policy*, **4**(2): 409-448.
Richardson, S., İ. Tuna and P. Wysocki (2010). "Accounting anomalies and fundamental analysis: A review of recent research advances." *Journal of Accounting and Economics*, **50**(2–3): 410-454.
Roulstone, D. T. (2008). "Insider Trading and the Information Content of Earnings Announcement." *Working Paper*.
Seyhun, N. (1998). *Investment intelligence from insider trading*, The MIT Press.
Soares, N. and A. W. Stark (2009). "The accruals anomaly – can implementable portfolio strategies be developed that are profitable net of transactions costs in the UK?" *Accounting and Business Research*, **39**(4): 321-345.
Timmermann, A. (1996). "Excess volatility and predictability of stock prices in autoregressive dividend models with learning." *The Review of Economic Studies*, **63**(4): 523-557.
Udpa, S. C. (1996). "Insider trading and the information content of earnings." *Journal of Business Finance & Accounting*, **23**: 1069-1095.
Veenman, D. (2012). "Disclosures of insider purchases and the valuation implications of past earnings signals." *The Accounting Review*, **87**(1): 313-342.
Veronesi, P. (1999). "Stock market overreactions to bad news in good times: a rational expectations equilibrium model." *Review of Financial Studies*, **12**(5): 975-1007.