Journal of Economic Behavior & Organization xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Journal of Economic Behavior & Organization

journal homepage: www.elsevier.com/locate/jebo

The role of surprise: Understanding overreaction and underreaction to unanticipated events using in-play soccer betting market

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ARTICLE INFO

Article history:
Received 31 December 2012
Received in revised form 9 February 2014
Accepted 13 February 2014
Available online xxx

JEL classification:
D84
G13
G14

Keywords:
Over/underreaction
Unanticipated events
Surprise
Conservatism
Prediction market
Bayesian dynamic model

ABSTRACT

Previous research in finance has found evidences of both overreaction and underreaction to unanticipated events, but has yet to explain why investors overreact to certain events while underreacting to others. In this paper, we hypothesize that while market participants generally underreact to new events due to conservatism, the extent of underreaction is moderated by "surprise," thus causing market participants to overreact to events that are highly surprising. We test our hypothesis using data from an in-play soccer betting market, where new events (goals) are clearly and exogenously defined, and the degree of "surprise" can be directly quantified (goals scored by underdogs are more surprising). We provide both statistical and economic evidences in support of our hypothesis.

1. Introduction

Financial researchers have long been interested in whether market participants react to unanticipated events in an unbiased manner,[1] or whether they exhibit behavioral biases such as overreaction (Brooks et al., 2003) or underreaction (Chan, 2003). While previous research has found evidences for both overreaction (Brooks et al., 2003; Coleman, 2011) and underreaction (Klibanoff et al., 1998; Chan, 2003), some of these evidences are somewhat conflicting or even contradictory. For instance, Brooks et al. (2003) show that markets tend to overreact to industrial disasters and CEO deaths, while Chan (2003) claims that investors underreact to headline news. In general, "clean" empirical evidences are difficult to find in

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[1] Similar to Brooks et al. (2003), we focus on events that are "unanticipated" both in terms of the timing and the nature of the event. Thus, we exclude scheduled events (e.g., earning announcements, layoffs) from our consideration, as some market participants may have gained (partial) access to such announcements ahead of time and hence create information asymmetry (Gil and Levitt, 2007).

http://dx.doi.org/10.1016/j.jebo.2014.02.009
0167-2681/

financial markets, as many phenomena can be viewed as evidences of opposite claims. For example, momentum in stock price (Jegadeesh and Titman, 1993) can be viewed as both the result of underreaction (Barberis et al., 1998; Hong and Stein, 1999) and overreaction (Daniel et al., 1998). More importantly, previous research has not specified the type of events (and the conditions under which they happen) where overreaction or underreaction is more likely to occur. This has been viewed as a serious limitation to behavioral finance theories by Fama (1998), who states that behavioral theories "must specify biases in information processing that cause the same investors to underreact to some types of events and overreact to others."

We develop a behaviorally motivated hypothesis of how investors underreact or overreact to unanticipated events. Specifically, we hypothesize that overreaction and underreaction are driven by conservatism (Barberis et al., 1998) and "surprise" (Reisenzein et al., 2012). When reacting to an event that is expected or only moderately surprising, market participants insufficiently update their prior beliefs due to conservatism and hence underreact (Barberis et al., 1998). In contrast, a more "surprising" event, i.e., an event that strongly violates prior expectations, attracts more cognitive processing (Meyer et al., 1997) as participants attempt to "make sense" of the incongruence between the observed event and their current schema (Pezzo, 2003). This in turn amplifies the surprising event and attenuates other sources of information (i.e., their prior beliefs), thereby resulting in a higher "weight" being put on the new event when forming a judgment. Thus, underreaction is moderated by surprise; for extremely surprising events, market participants overweight the new information, leading to overreaction.

Testing our hypothesis on financial market data is challenging because it is difficult to a priori quantify how "surprising" an events is (Barberis et al., 1998) and to unambiguously measure its impact on equity prices (Fama, 1998). Thus, we turn to data from an "in-play" soccer betting market to test our hypothesis (Avery and Chevalier, 1999). In an in-play sports betting market, participants place bets while a match is still under way. It offers the ideal setting to test our hypothesis for several reasons: first, the arrival of a goal is apparent and its impact on odds can be objectively assessed with actual match outcomes; this circumvents the problem in financial markets where market efficiency has to be jointly tested with a model of expected "normal" return (Fama, 1998). Second, unlike in financial markets where there can be a long delay between media reporting and the occurrence of an unanticipated event (Coleman, 2011) and hence involve information asymmetry issues, goals are reported as soon as they are scored and immediately become public knowledge among all market participants. Third, we can clearly define how "surprising" a goal is by comparing the strengths of the two teams: a goal scored by the "underdog" is more surprising than a goal scored by the "favorite." Fourth, goals are exogenous shocks, which may not be the case in financial markets.[2] Finally, real money is at stake in a betting market and transactional volume is condensed within a short time horizon, which provides a large sample of events in a real-world setting to test our hypothesis.

Our dataset is comprised of second-by-second transaction records in 2017 soccer matches obtained from Betfair, an online betting exchange. The total betting volume in our sample amounts to around £3 billion. While a match is under way, participants may bet on the outcomes "team1 win", "draw", or "team2 win"; we focus on the in-play odds of the scoring team. We operationalize how "surprising" a goal is by the difference between the implied winning probability of the non-scoring team and that of the scoring team, measured right before the goal. We study overreaction and underreaction to the first goal of the match using a sequence of logistic regressions and a Bayesian structural model. In general, we find that market participants underreact to goals that are expected or only moderately surprising. This underreaction is moderated by the degree of surprise, resulting in overreaction to very surprising goals. We find that these biased reactions attenuate over time and disappear at around 5 min after the goal, but are unrelated to transactional volume. In addition, we explore the economic size of the mispricing bias by developing a strategy that bets on the scoring team when underreaction is predicted, and against the scoring team if overreaction is predicted. Through a split-sample analysis, we find that such strategy earns a profit of 2.46% ($p = 0.03$) after commissions if the bets are placed at 2 min after the goal, suggesting that underreaction and overreaction are economically significant.

The remainder of this paper is organized as follows. Section 2 briefly reviews previous research on overreaction and underreaction to unanticipated events, the role of surprise in judgment and decision making, and the sport betting markets. Section 3 describes our hypothesis of how conservatism and surprise drive underreaction and overreaction. Section 4 describes our dataset along with key summary statistics. In Section 5, we present statistical and economic evidences on overreaction and underreaction. Finally, Section 6 concludes with implications for financial markets.

2. Background and conceptual development

2.1. Overreaction and underreaction in financial markets

As discussed earlier, previous research has found evidences for both overreaction and underreaction. For instance, Brooks et al. (2003) study stock market reactions to 21 unanticipated events, e.g., the sudden death of CEOs. They find that the initial price reaction to an unanticipated event tends to be partially reversed in 90 min after the event, suggesting initial overreaction. Similarly, Coleman (2011) analyzes initial stock market response to 60 "shock" corporate events such as fatal

[2] Coleman (2011) shows that the timing of initial announcement following an unanticipated event depends on firm-specific factors such as capital intensity and age of the CEO. More generally, company information release may depend on managers' perceptions of the firm being over or undervalued, and thus can be endogenous.

Please cite this article in press as: Choi, D., Hui, S.K., The role of surprise: Understanding overreaction and underreaction to unanticipated events using in-play soccer betting market. J. Econ. Behav. Organ. (2014), http://dx.doi.org/10.1016/j.jebo.2014.02.009