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PRIVATE INFORMATION, OVERCONFIDENCE AND TRADER RETURNS IN PREDICTION MARKETS

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ABSTRACT

In lab experiments on the value of information in financial markets, groups of "insiders" are randomly chosen to receive perfect information. However, in typical (non-experimental) financial markets, investors often engage in extensive fundamental analysis, a process which may result in over-confidence in one's private information. In this study, we examine trading volume, prices and trader returns in a set of four real money prediction markets where the values of securities are tied to a movie's box office performance. Before the markets opened, every trader submitted a detailed forecast of the movie's future performance. Therefore, all traders have self-generated private information, the accuracy of which can only be known *ex-post*.

Trading volume and timing were consistent with over-confidence. In three of the four markets, contract prices were consistent with the prior information equilibrium, another indication of trader over-confidence in their private information. In those three markets, traders whose forecasts were associated with the winning contract had significantly higher returns than traders with less accurate forecasts. In the fourth market, there were no significant differences in returns.

This research shows how having different private information across traders produces winners and losers. Gathering private information leads to over-confidence across all traders regardless of the *ex-post* accuracy of their forecast. When all traders are over-confident, those with a better forecast do not have to be certain of their informational advantage to profit from it. In comparison, despite their efforts and confidence in their private information, traders with worse information have significantly worse outcomes.

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1 INTRODUCTION

The controversy over the role of information in financial markets has been active for almost four decades. Fama (1970) famously declared that market efficiency makes information gathering useless (or at least profitless) since all information is revealed by market prices. Since that time, there has been a continuing debate on the topic. For example, Grossman (Grossman 1976; Grossman and Stiglitz 1980) suggests that fully efficient markets cannot exist since a lack of returns would prevent anyone from gathering costly information. Without such efforts, the market would have no information to reveal through prices. This is a central issue in finance given the enormous resources devoted to fundamental security analysis (Figlewski 1982) and the continuing belief that "information is the most important ingredient to achieve above-average returns" (Huber 2007: 2538).

In a separate stream of research, behavioral finance researchers have focused their attention on the effects of individual biases as an explanation for differences in investor returns. For example, studies of individual brokerage accounts show that increased trading activity due to overconfidence leads to lower investor returns (Barber and Odean 2000). In related research, overconfidence has been associated with past investing success (Barber and Odean 2002) and gender (Barber and Odean 2001a).

In this paper, we build on these important streams of research by examining how overconfidence and disparate private information affect trader returns in prediction markets. The source of overconfidence we consider is the effort made by a trader to generate a forecast, i.e. fundamental analysis. When trading, overconfident investors rely heavily on their private information (Daniel, Hirshleifer and Subrahmanyam 1998) leading to a high volume of trading (Odean 1998). If this is the case, market prices would be consistent with the prior information equilibrium, i.e. reflecting the distribution of the traders' private information (Plott and Sunder 1982; Huber 2007). In such situations, we expect that traders with more accurate forecasts should have significantly higher returns than traders with less accurate forecasts.

We test our conjectures using data from a small-scale, real money prediction market operated by a U.S. university as a research and teaching tool. Our focus is a set of 4 movie box office futures markets conducted in 1998 and 2000. In each market, a set of 4-5 Arrow-Debreu contracts were offered. The payoff for each contract was tied to a range of 4-week box office results for the focal movie. All of the traders in these markets were graduate business students who, in exchange for their trading accounts, created and turned in detailed forecasts before trading began. Using this unique data, we can examine how differences in forecast accuracy affect trader returns when all traders have engaged in fundamental analysis, albeit of future movie box

office receipts as opposed to the future performance of securities in equity capital markets.

We examined the returns of traders based upon which contract their forecast suggested would finish in the money. In three of the four markets we studied, the market prices of the contracts were consistent with the prior information equilibrium. In those markets, traders whose forecasts were associated with the winning contract had significantly higher returns than traders whose forecasts suggested that another contract would pay off. In the one market where prices were not consistent with the prior information equilibrium, there were no significant differences in returns between the traders associated with the winning contract and the other traders.

The contributions of this study lie in two areas. First, we show that when all traders have engaged in fundamental analysis before the onset of market participation, the volume and timing of trading as well as the resulting market prices are consistent with the analytical models of how trader overconfidence affects financial markets (Odean 1998; Daniel et al. 1998). We add to the laboratory research on the value of information in financial markets (Ackert, et al. 2002; Copeland and Friedman 1992; Huber 2007; Huber, et al. 2008; Plott and Sunder 1982) by showing that traders who have more accurate information have significantly higher returns even when the traders' informational advantage can only be known *ex-post*. This is an important finding since in most prior research the information advantage provided to "insiders" was substantial (i.e., perfect information) and this information advantage was common knowledge among the other traders. When all traders are overconfident and trade accordingly, there can be significant rewards to being better informed.

The balance of the paper proceeds as follows: Section 2 reviews prior research on the value of information in markets, the relationship between effort and overconfidence and the effects of overconfidence. Section 3 provides background information on the movie box office futures markets. In Section 4, we present our results. Section 5 concludes with a discussion of our findings.

2 THE VALUE OF INFORMATION IN FINANCIAL MARKETS

In his seminal 1970 paper on the efficient market hypothesis, Fama (1970) suggests that efforts by investors to gather information would be fruitless since all information is already reflected in market prices. The fully-revealing nature of prices under strong form market efficiency leads to a paradox, first described by Grossman and Stiglitz (Grossman 1976; Grossman and Stiglitz 1980). If better informed traders are unable to benefit from their superior information, what is the incentive to gather costly information? Clearly, none exists in a fully efficient market. However, if no one has the incentive to

gather costly information, the market would have no information to reveal through prices.

One way to resolve this paradox is to assume that markets are populated with asymmetrically informed traders. For example, Radner (1979) shows that when traders have different information about the value of a financial security, trading will reveal the information held by a sub-set of traders to all traders. These findings suggest that, under the rational expectations equilibrium (REE), better informed traders will have the same returns as less well informed traders.

An experimental study by Plott and Sunder (1982) confirms that uninformed traders are able to learn from the actions of perfectly informed "insiders." The prices in these markets converged to a fully-revealing REE. Furthermore, consistent with the efficient market hypothesis, there were no significant differences in returns between informed and uninformed traders.

Since then, a number of authors have studied the interactions between informed and uninformed traders (e.g. Ackert, Church and Zhang 2002; Copeland and Friedman 1992). More recently, Huber and his colleagues (Huber 2007; Huber, Kirckler and Sutter 2008) have been considering whether having more information can actually hurt a trader's returns. They base their studies on a model by Schredelseker (2001) in which a fully informed insider can earn higher returns from his informational advantage while completely uninformed traders earn the market return. This implies that traders with some level of information between complete ignorance and complete information must have returns less than the market average.

In their market experiments, Huber and his colleagues vary the amount or timing of information provided to traders. In Huber, Kirckler and Sutter (2008), they find that having more information - short of complete information - does not necessarily increase a trader's returns. When information timing is manipulated across traders (Huber 2007), the returns have a J-shape, showing that traders receiving information somewhat later have significantly lower returns even when compared to traders receiving the information with a longer time lag. These results are very interesting since they show that relaxing the assumption of two levels of information (informed and uninformed) leads to an advantage that insiders could consistently exploit, a result at odds with the theory of the REE and the experimental findings of Plott and Sunder (1982).

The presence of informational "insiders" is a critical abstraction in the theoretical and experimental research on the value of information in financial markets. In the experimental research, insiders are randomly selected to receive perfect information. Given *ex-ante* perfect information, these inside traders can be confident of their advantage over others. However, the clear advantage of these insiders raises an important question: What happens when traders can only know the accuracy of their information *ex-post*? Are better informed traders able to benefit from an information advantage that is only revealed *ex-post*?

With *ex-ante* perfect information, traders can have complete confidence in the value of their information. Moreover, this advantage is unearned. However, in traditional financial markets, traders decide how much effort (or expense) to expend on information gathering (Huber 2007). Therefore, a logical next step in this stream of research is to examine endogenous differences in information across traders (Huber 2007: 2561).

We expect that the uncertainty introduced by self-generated information raises the possibility that traders will overestimate the value of their information and trade in an overconfident manner. Extant studies of actual individual behavior (e.g. Barber and Odean 2000; 2001a; 2002) reveal that investors frequently exhibit over-confident behavior. However, these studies lack reliable measures of informational differences across traders. Therefore, it is unclear the extent to which some of the observed variations in investor returns may be attributed to information asymmetries rather than overconfidence.

In our study, we explore a middle ground between the abstractions of the experimental work and the inability to measure differences in information across individual stock market investors. In contrast to the experimental research, our traders come to the market with *different, self-generated* private information which we measure before trading begins. They do not know *a priori* the accuracy of their forecasts. In the next section, we argue that the process of engaging in fundamental analysis will make traders overconfident. We expect this overconfidence will affect the volume and timing of trading, observed market prices and, ultimately, the returns to better information.

2.1 EFFORT AND OVERCONFIDENCE

In experimental markets, one's informational advantage is generally not due to one's efforts, i.e. due to random assignment. In conventional financial markets, investors may commit a great deal of effort to fundamental analysis in order to improve one's returns (Barber and Odean 2001b). Research on the psychology of decision making suggests that such efforts are likely to make one overconfident in the accuracy of any information that is generated by the individual (Paese and Sniezek 1991).

People expect that a high level of effort should result in better performance. For example, Yates and Kulick (1977) show that subjects believe that returns to effort increase at an increasing rate. In Switzer and Sniezek (1991), subjects believe the relationship between their effort and output on clerical tasks to be strong and positive. In reality, output does not always vary with effort.

When forecasting a future event, a person may expect a positive relationship between one's efforts and forecasting accuracy. While performance can increase with increased effort for many tasks, there is no reason to expect that increased efforts can result in more accurate forecasts of uncertain future events (Paese and Sniezek 1991). In a study of forecasting the

future performance of baseball pitchers, Paese and Sniezek (1991: 118) find that "when highly uncertain quantities are predicted, confidence may increase with self-assessments of effort, even though accuracy may be unlikely to improve." In fact, "(d)espite higher confidence, those who reported high effort were not necessarily more accurate, as there was no relation between effort and accuracy in predictive judgment" (Paese and Sniezek 1991: 124).

In a controlled lab experiment, Cipriano (2006) compared the efforts of subjects required to supply an explanation of their fundamental analysis of the earnings of a company with those who are not required to supply such an explanation. He found that the explanation requirement lead to significantly more effort. Effort was measured by the amount of time that subjects spent viewing information relevant to the company for whom the forecast was being created. The correlation between explanation requirement and time spent viewing information was positive and significant (0.53, $p < 0.0001$). This study suggests that when the act of forecasting a future outcome is accompanied by an explanation of the forecast, traders will put significantly more effort into their forecasts.

In the context of fundamental analysis, we expect that when investors are asked to justify their forecast of a future event, the investors will put a great deal of effort into this task. Due to a high level of effort, they will be highly confident of their forecast. In fact, we expect that the high level of effort will lead to overconfidence on the part of the individual trader. This overconfidence will be manifested in the market in multiple ways, discussed in the next section.

2.2 THE EFFECTS OF OVERCONFIDENCE

Once one has made a judgment, one's confidence can affect how new information is processed (Shaklee and Fischhoff 1982). In a market setting, this would mean that traders would primarily rely on their private information rather than update their forecast using information from other traders (or public information) as communicated by market prices (Odean 1998; Daniel et al. 1998).

Under the fully revealing REE, price is a sufficient statistic for all information (Sunder 1995). All traders would become quickly informed of the intrinsic values of the market securities and there would be little, if any trading absent significant differences in liquidity needs or risk preferences (Grossman and Stiglitz 1980; Kyle 1985). In contrast, if overconfident traders bring heterogeneous information to the market and trade based on this information, we would expect a high volume of trading (Odean 1998).

At the aggregate level, we expect that prices in a market populated by overconfident traders would be consistent with the prior information equilibrium (Forsythe et al. 1982, Plott and Sunder 1982; 1988; Huber 2007). The prior information equilibrium arises when traders focus solely on their private information. They, "ignore the possibility that market prices, by

aggregating information from other traders, also contain information," (Palan 2009: 26-27).

Overconfidence leads traders to put more weight on one's own forecasts versus those of others (Daniel et al. 1998). Furthermore, overconfident traders will rely more upon private information that he or she has personally created than on publicly available information (Daniel et al. 1998). Trading solely on private information should results in prices consistent with the prior information equilibrium.

Finally, we expect that investors trading on the basis of disparate private information will have varying returns depending on whether their original forecasts were accurate or not. This would be consistent with markets where traders had different timing of information (Huber 2007). In those markets, when traders used "naïve trading" or trading based on their own private information, the distribution of returns reflected the variations in information timing across groups of traders who obtained information earlier profiting at the expense of traders who had to wait for information (Huber 2007: 2545). When traders bring their own information to a market, we expect that those with more accurate forecasts should be able to leverage their informational advantage and profit from trading with others whose forecasts are less accurate.

3 MARKET OVERVIEW

The setting for our study is a small-scale, real money futures market operated by a U.S. university. Participants may trade futures contracts whose value is tied to a future event such as a political contest, changes in Federal Reserve policy or the box office performance of a movie.

All trading is conducted via an anonymous, computerized double auction which accepts both market and limit orders. All limit orders (bids/asks) are queued by price and submission times. The best bid and ask prices are available to traders as are past daily average prices and transaction levels. An individual's investment in the market is limited to $500 and no short selling is allowed. In addition, no transactions fees are charged to traders.

Traders may acquire contracts from the market in a bundle consisting of one of each of the contracts in the market. A complete bundle of contracts may be purchased from or sold to the exchange at any time for $1, the guaranteed liquidation value of the bundle. Therefore, the supply of contracts in the market expands and shrinks as traders desire without contaminating the individual contract prices as set by the traders.

3.1 MOVIE BOX OFFICE MARKETS

We focus on a set of four movie box office markets that were offered to traders in 1998 and 2000. Each market was intended to predict the domestic box office performance of a particular movie in its first 4 weeks of release. In

each market, a bundle of four or five contracts was offered. Each contract is associated with a mutually exclusive and collectively exhaustive range of box office receipts within the specified four-week period.

For example, in a market conducted in the fall of 1998, there were 4 contracts associated with the movie *Enemy of the State*. Their definitions are given in Figure 1.

Figure 1: Contracts in the *Enemy of the State* Market

EOS25L	$1.00 if "Enemy of the State" domestic box office receipts for the 11/20-12/17 period are lower than or equal to $25 million; zero otherwise
EOS40L	$1.00 if "Enemy of the State" domestic box office receipts for the 11/20-12/17 period are higher than $25 million and lower than or equal to $40 million; zero otherwise
EOS55L	$1.00 if "Enemy of the State" domestic box office receipts for the 11/20-12/17 period are higher than $40 million and lower than or equal to $55 million; zero otherwise
EOS70L	$1.00 if "Enemy of the State" domestic box office receipts for the 11/20-12/17 period are higher than $55 million and lower than or equal to $70 million; zero otherwise
EOS70H	$1.00 if "Enemy of the State" domestic box office receipts for the 11/20-12/17 period are higher than $70 million; zero otherwise

At the end of the market, only one of the contracts pays off $1 while the others expire worthless. Therefore, the bundle of contracts is a set of outcome-spanning Arrow-Debreu securities. Prior research by Plott and Sunder (1988) suggests that asset markets using this contract framework can successfully aggregate information from individual traders.

3.2 TRADERS AND FUNDAMENTAL ANALYSIS

In these movie box office markets, all traders were graduate business students who were provided a $10 trading account (They could add more

funds to the $500 market limit). In exchange, these traders were required to submit a forecast of the 4-week box office performance supported by a 2-4 page justification. (A sample assignment and further details are available from the authors.) In addition, these traders were also asked to execute at least two transactions while the market was open (buying or selling a bundle of contracts is considered a transaction).

Prior research suggests that an explanation requirement elicits more cognitive effort on the part of subjects in a wide variety of settings (e.g., Ashton 1990; Chang et al. 1997; Tuttle et al. 1997). In the context of financial forecasts, Daniel et al. (1998 : 1841) suggest that an investor will be, 'more overconfident about signals or assessments with which he has greater personal involvement." Consequently, we expect that all traders in our markets will be overconfident of the accuracy of their forecasts.

We have a limited amount of survey data from traders in the 2000 movie box office markets to support this assertion. After the forecasts were submitted and before the market opened, the student traders completed a short survey. The survey included questions assessing their confidence in the accuracy of their forecast for each movie as well as perceived time spent and information used to complete the forecasting assignment (relative to other students). In addition, the students were asked about their anticipated trading activity and interest in seeing the movies. The survey questions are available from the authors.

The survey results are consistent with our assumption that increased effort leads to overconfidence. For both movies (*How the Grinch* and *The 6th Day*), the majority of traders indicated they were somewhat confident or very confident that their forecast was accurate (86%, 77% respectively). For both movies, confidence in forecast accuracy was significantly correlated ($p < 0.001$) with the perceived time spent ($r = 0.40$, 0.31 respectively) and amount of information used ($r = 0.43$, 0.30 respectively). While limited, this survey data supports our conjecture that the time and effort one expends in creating and justifying a forecast will lead to overconfidence in its accuracy.

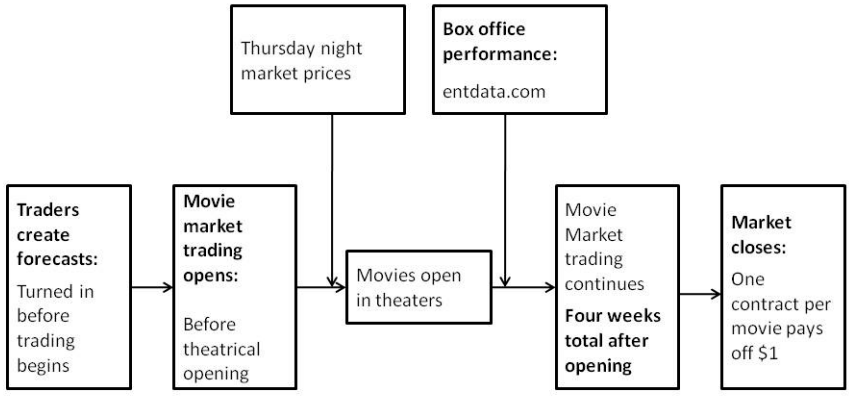
The first step in the market timeline is the submission of the traders' forecasts. Once the forecasts are turned in to the experimenter, the movie box office market opens. Trading began up to two weeks before the opening of the movie in theaters (all of these movies opened on a Friday). Once the movie opened in theaters, trading continued for four weeks.

Nielsen/EDI (entdata.com) tracked movie box office performance on a weekly basis. Daily estimates are also available at other web sites, e.g. the-numbers.com. After the final 4-week receipts are available in print (through Variety), the markets are liquidated. This entails exchanging $1 for each winning contract held by a trader. Nothing is paid for losing contracts.

3.3 MARKET TIMELINE

The timeline of the market is provided in Figure 2.

Figure 2 Market Time Line



4 RESULTS

Our study focuses on four movie box office markets. Two of these markets were offered in 1998 and two in 2000. Details about the markets are provided in Table 1

Table 1: Overview of Movie Box Office Markets

Movie	*I Still Know What You Did Last Summer*	*Enemy of the State*	*How the Grinch Stole Christmas*	*The Sixth Day*
Date market opened	11/9/1998	11/9/1998	11/3/2000	11/3/2000
Date movie opened in theaters	11/13/1998	11/20/1998	11/17/2000	11/17/2000
Date market closed	12/10/1998	12/17/1998	12/14/2000	12/14/2000
Number of contracts	4	5	5	5
Number of traders	83	87	86	82
Number of contracts traded *	1439	2392	1468	798
Proportion of contracts traded before movie opening	41%	64%	74%	66%

* Bundles of contracts excluded

In these markets, every trader generated a written forecast for both movies. However, the traders were free to choose in which markets they would participate. This accounts for the differences in the number of traders across markets.

4.1 TRADING VOLUME AND TIMING

We conjecture that their forecasting efforts would result in trader overconfidence. One of the indicators of overconfidence is a high volume of trading activity. Note that traders were only required to make two trades which included the buying or selling of a bundle of contracts. However, the overall average number of trades was very high. There were a total of 88 traders in the 1998 markets (*I Still Know* and *Enemy of the State*) who traded a total of 3831 contracts, an average of 43.5 contracts per trader. The 91 traders in the 2000 markets (*How the Grinch* and *The 6th Day*) traded an average of 24.9 contracts. These volume figures do not include buying contract bundles from or selling bundles to the exchange. This high volume of trading is consistent with overconfidence.

To determine if the traders were overconfident as a group, we examined the timing of trading in the markets. Before a movie opens in theaters, there is little public information for traders to incorporate into prices. During the time between the commencement of trading and the opening of the movie in theaters, much of the trading would be driven by differences in private information across traders. In contrast, once a movie opens in theaters, there is a great deal of public information available to traders to determine which contract will finish in the money. For example, the results from the first weekend's box office provide a very revealing signal regarding the 4-week total box office performance (Krider and Weinberg, 1988; Pennock et al. 2001).

Given the information content of the first weekend's performance data, a rational trader who is unsure of the accuracy of his or her forecast would wait until estimates of these results become available (Copeland and Freidman 1987). In contrast, overconfident traders would focus more of their trading activity in the pre-opening period to position their portfolios to benefit from their perceived informational advantage over other traders.

To assess the timing of the trading in these markets, we compared the volume of contracts traded before a movie opened in theaters to the total volume of contracts traded for the entire time period of the market (See Table 1). This proportion ranged from 41% in the *I Still Know* market to 74% in the *How the Grinch* market. Given the concentration of trading before reliable public information is available to traders, we conclude that the timing of trading volume in these markets is consistent with overconfidence.

4.2 EVIDENCE OF PRIOR INFORMATION EQUILIBRIUM

Overconfident investors are more likely to base their trades on their private information rather than either public information or the private information of other traders (Daniel et al.1998). Unlike experimental markets (e.g. Plott and Sunder 1982; Huber 2007), we do not provide traders with their private information. By controlling the trader's information and through the design of their securities, these authors create a clear distinction in prices between the REE and the prior information equilibrium. For our markets, we are limited to testing whether there are significant deviations in the observed market prices from those we would expect under the prior information equilibrium.

If, as we assume, traders in these markets are primarily using their private forecasts to guide their trading, then we should expect that the distribution of forecasts would be reflected in the distribution of contract prices, i.e. the Walrasian equilibrium (Grossman 1981: 546-548). For example, consider the market for the *Enemy of the State* movie. If 50% of the traders predict that the movie would make $70 million or more in its first 4 weeks of release, then we should expect that the price for the corresponding contract would be $0.50.

For each movie, we partitioned the distribution of the traders' point forecasts using the same cut points as the contracts in the movie box office markets. (Note that the traders did not know how the contracts would be defined before trading began.) For comparison, we computed the (normalized) last transaction prices at midnight on Thursday before the movie opened in theaters. We compared the cumulative distributions of the trader forecasts and the contract prices using the one-sample Kolomogrov-Smirnov D test. The sample size was the number of trader forecasts. The results are presented in Table 2.

The null hypothesis (H_0) for this non-parametric test is that the distribution of forecasts is the same as the distribution of contract prices. This would result from traders relying on their private information. We fail to reject this hypothesis for three of the four movies ($p < 0.05$). For the movie *I Still Know*, the difference is significant at the $p < 0.05$ level. These findings suggest that, consistent with overconfidence, contract pricing in three of the markets does not significantly differ from prices we would observe under the prior information equilibrium. The correspondence between the observed contract prices and distribution of point forecasts is surprisingly close given we do not have to control for individual differences across traders (e.g. trading activity, wealth, etc.).

4.3 TRADER RETURNS

To measure the returns for the individual trader, we used a simple measure similar to operating margin. The numerator consists of the proceeds of all contract sales, bundle sales to the exchange and proceeds from the

liquidation of winning contracts. The denominator consists of payments to the exchange for bundles and individual contracts purchased from other traders. A trader who breaks even has a return of 1 while one who makes (loses) money has a return of more (less) than 1. By construction, the return for the market as a whole is unity. This measure accounts for differences in the amount of trading activity across investors. Furthermore, we ignore any discounting since the $1 risk-free bundle of contracts sells for $1 for the duration of the market. This implies that the risk-free alternative in this market bears a zero interest rate (Bonderenko and Bossaerts 2000).

Table 2: Comparison of Distribution of Trader Forecasts and Market Contract Prices

Market Contracts	Proportion of Trader Forecasts within Contract Limits	Normalized Thursday Night Contract Prices	Kolomogrov-Smirnov Statistic
I Still Know…			
			Maximum
ISK20L	3%	0.13	difference = 0.1499
ISK35L	22%	0.17	
ISK50L*	33%	0.43	$D_{K\text{-}S,0.05}$ =0.1427
ISK50H	42%	0.27	
			Reject H_0
Enemy of the State			
			Maximum
EOS25L	2%	0.001	difference = 0.11
EOS40L	7%	0.005	
EOS55L	14%	0.11	$D_{K\text{-}S,0.05}$ =0.1427
EOS70L	9%	0.23	
EOS70H*	68%	0.66	Fail to Reject H_0
How the Grinch...			
			Maximum
GRIN70L	10%	0.16	difference = 0.06
GRIN90L	11%	0.08	
GRIN110L	27%	0.29	$D_{K\text{-}S,0.05}$ =0.1404
GRIN110H*	52%	0.47	
			Fail to Reject H_0
The Sixth Day			
			Maximum
SIX50L*	14%	0.24	difference = 0.098
SIX70L	42%	0.42	
SIX90L	32%	0.32	$D_{K\text{-}S,0.05}$ =0.1404
SIX90H	11%	0.02	
			Fail to Reject H_0

* indicates contract that paid $1 (winning contract).

The volume of trading activity and the timing of trades are consistent with overconfident traders in all four markets we studied. In three of these markets, the contract prices before the movies opened in theaters are consistent with the prior information equilibrium. In the fourth market (*I Still Know*), the observed market prices differ significantly from the distribution of traders forecasts.

If overconfident traders are primarily relying on their private information (i.e., forecasts), then traders whose forecasts lie within the boundaries of the winning contract should have higher returns. We compared the average returns for traders with accurate forecasts - those whose forecasts fell within the boundaries of the contract that ultimately finished in the money - with all other traders. Since the returns are not normally distributed, we used the Mann-Whitney U-test. The results are presented in Table 3.

Table 3: Comparison of Trader Returns

Movie Market	**Average return for traders with forecasts within bounds of winning contract[1]**	**Average return for traders with forecasts outside bounds of winning contract[1]**	**Mann-Whitney U-Test[2]** **Standardized Test Statistic**
I Still Know What You Did Last Summer	1.08 (28)	0.95 (55)	1.59 (0.11)
Enemy of the State	1.07 (60)	0.69 (27)	3.03 (0.001)
How the Grinch Stole Christmas	1.14 (39)	0.70 (47)	4.08 (0.000)
The Sixth Day	1.67 (12)	0.64 (70)	2.57 (0.01)

1 Sample size in parentheses
2 p-value in parentheses

As expected, the average returns for traders with accurate forecasts were significantly higher ($p < 0.03$) in the three markets (*Enemy of the State*, *How the Grinch*, *The 6th Day*) in which pricing is consistent with the prior information equilibrium.

Furthermore, we find that this same comparison is not significant ($p < 0.11$) for the *I Still Know* market. This should not be a surprise since the prices in this market are not consistent with the prior information equilibrium. In such a situation, we should not expect there to be a significant difference in trader returns based on private information.

There are two possible explanations for the results we observe in the *I Still Know* market. One possibility is that the market was actually converging to prices consistent with the REE. This would be indicated by the difference of 10% between the price of the winning contract (ISK50L) and the proportion

of traders whose forecasts fell within the boundaries of that contract. However, there was a much larger difference (as a percentage) associated with the lowest denominated contract (ISK20L). While only 3% of trader forecasts fell within that contract's boundaries, its normalized price was 4 times higher at 0.13.

A second possible explanation is due to the short duration of the pre-opening period, i.e. between the beginning of trading and the opening of the movie in theaters. In the *I Still Know* market, that time period was only 4 days. The comparable time periods for the other markets were 10-14 days. It is possible that the market did not have time to converge to the expected prior information equilibrium.

Table 4: Trader Returns by Contract Interval

Market Contracts	Average returns for traders with forecasts within contract limits	Mann-Whitney U-Test p value of comparison with returns for traders associated with winning contract
Enemy of the State		
EOS25L	0.28	0.051
EOS40L	0.57	0.041
EOS55L	0.64	0.009
EOS70L	0.94	0.295
EOS70H*	1.07	--
How the Grinch...		
GRIN70L	0.55	0.006
GRIN90L	0.79	0.002
GRIN110L	0.71	0.004
GRIN110H*	1.14	--
The Sixth Day		
SIX50L*	1.67	--
SIX70L	0.52	0.009
SIX90L	0.59	0.015
SIX90H	1.21	0.422

* indicates contract that paid $1 (winning contract)

To better understand the relationship between forecast accuracy and trader returns, we segmented every market into four or five groups based on the number of contracts offered in the market. The statistical tests reported in Table 3 evaluate the returns of traders with accurate forecasts with those of traders whose forecast did not fall within the bounds of the winning contract. We expect that if a group of trader forecasts are far from the range embodied by the winning contract, their returns will be lower.

We tested this hypothesis by comparing the returns from the traders with accurate forecasts with separate groups of traders, each defined by having a forecast within the range of a given contract. Since the returns are not normally distributed (and sample sizes can be small), we used the Mann-Whitney U statistic. The results are presented in Table 4. (Note that we did not include the returns in the *I Still Know* market. They are available from the authors).

We see that for every market, the average return for traders with an accurate forecast are higher than the average for any other group of traders. In the *Enemy of the State* market, returns for all groups of traders whose forecast fell below $55 million had significantly lower returns ($p < 0.051$). For the group of traders with forecasts falling between $55 million and $70 million, the difference was not significant ($p < 0.295$).

In the market for *How the Grinch Stole Christmas*, the average returns for all groups of traders whose forecasts fell below $110 million were significantly lower ($p < 0.006$).

For traders in the market for *The Sixth Day*, forecasting a 4-week total between $50 million and $90 million resulted in a significant reduction in returns. It is interesting to note that the average returns for the small group of traders with a forecast exceeding $90 million is not significantly different from those with an accurate forecast ($p < 0.422$).

One possible reason for this outcome is that some of these traders abandoned their forecasts and incorporated information from the other traders. For example, one of the traders in this group made only one purchase during the entire market. Fortunately, the contract that was purchased for $0.22 turned out to be the winning contract resulting in a return of 4.54. While such behavior is inconsistent with overconfidence, it suggests that, while traders tended to be focused on their own private information, there are important variations in individual behavior.

Examining the pattern of returns based on the proximity to the winning contract, we see two things. First, of the 10 groups of traders whose forecast lay outside the range of the winning contract, the average returns for 8 of the groups are significantly worse than the average returns for traders with accurate forecasts ($p < 0.051$). Second, of the 2 groups with average returns comparable to the traders with accurate forecasts, one is associated with a contract directly adjacent to the winning contract (EOS70L). Based on these results, we conclude that the further away a trader's forecast is from the boundaries of the winning contract, the more likely it is that trader will have significantly lower returns.

If we combine the results from Table 4 with the forecast distributions from Table 2, we see that the proportions of traders whose returns seem to have been affected by the *degree of inaccuracy* of their forecasts are, in time order, 23% (*Enemy of the State*), 48% (*How the Grinch*), and 75% (The *Sixth Day*). The results from Table 4 combined with the findings presented in Table 3 suggest that when traders are overconfident (as a group), fundamental

analysis can be very beneficial if your efforts result in accurate information. For most traders who did not generate an accurate forecast, the efforts towards fundamental analysis were not only profitless but, ultimately, return reducing.

5 DISCUSSION AND CONCLUSIONS

This study differs from current research about the impact of information on trading outcomes in a number of important ways. First, the information asymmetries across traders arose naturally and were not due to random chance as in prior lab experiments. Second, the accuracy of a trader's private information can only be known *ex-post*, as is the case in traditional financial markets. Third, and most critical, a trader's private information was a result of the time and effort he or she took to prepare a forecast and justify it in writing. This very task makes a trader overconfident in the quality of one's private information which is a central focus of research in behavioral finance (Odean 1998; Daniel et al. 1998). In this unique setting, we are able to measure a traders' private information and examine its impact on trading in a setting where "all traders are above average" (Odean 1998). Thus, we have much of the realism of larger financial markets (disparate private information, overconfidence born of reliance on personally created private information, real money incentives) combined with many of the controls of market experiments (finite lived assets, Arrow-Debreu securities, measures of private information).

We find that, motivated by their efforts towards developing and justifying their forecasts, traders in these futures markets act in a manner consistent with over-confidence. The levels and timing of trading exceed those we would anticipate if traders had acted rationally under high levels of uncertainty (Copeland and Friedman 1992). Every trader was personally responsible for conducting a fundamental analysis of a financial outcome that determined the value of the contracts traded in the futures markets (i.e. the forecasting assignment). Consistent with Daniel et al. (1998), these traders focused on their own private information as indicated by prices consistent with the prior information equilibrium in three of the four markets we studied. In the markets where prices reflected the distribution of private information, the group of traders with accurate forecasts had significantly higher returns than traders with inaccurate forecasts. In the market wherein prices were not consistent with the prior information equilibrium, we did not observe significant differences in trader returns.

The results in this paper suggest an alternative way to view the results in Huber (2007) about the value of more timely information. In Huber (2007), trading activity, market prices and trader returns were more consistent with the prior information equilibrium ("naïve trading" in his paper) than the REE. However, there is little discussion about why this is so. One unexplored possibility is that, despite the detailed instructions, traders did not understand the information structure. Another possible explanation is overconfidence.

It may be that the less well-informed traders in the market were overconfident in their ability to use prices to infer information possessed by the insiders. Our study shows that traders with more accurate forecasts were able to take advantage (through trading) of overconfident traders with less accurate forecasts. In Huber (2007), overconfidence on the part of the traders who received less timely information led them to trade even though they were at a known disadvantage versus the insiders. In both settings - our markets and Huber (2007) - it is the presence of overconfident, less well informed traders that enables traders with better information to gain from their advantage whether it was earned through effort or the result of random chance.

Like all empirical studies, this work has potential limitations. The subjects are not professional traders. However, such equivalents do exist in larger financial markets. Perhaps our traders are more representative of the individual investor rather than professional institutional investors. It may be that these naïve investors are a source of lower quality or more widely varying information in markets. An additional concern may be the subject of the fundamental analysis, i.e. the box office performance of a particular movie. Unlike traditional financial instruments, each movie is unique and there is not a historical distribution of returns available to traders.

Information plays a central role in finance. At the micro-level, the prices of traded assets convey information to traders and to observers of a market. At the macro-level, a very large part of the financial services industry is dedicated to providing information to investors. Despite the availability of such information, our understanding of whether a trader's private information can be translated into better returns is quite limited. Due to the unique characteristics of these prediction markets and their participants, we can shed some light on the interactions among private, overconfidence and trader returns.

Our study helps inform the debate regarding the role of information in financial markets. The requirement that traders engage in pre-trading forecasting enabled us to use our prediction markets to not only predict the box office performance of the movies but also to provide insights into the ways that information influences trading behavior and trading outcomes. The prospect for gain from having a better forecast motivated traders in our prediction markets to engage in fundamental research regarding the eventual outcome. Traders ended up having very different private information (i.e., forecasts) with respect to the value of the securities being exchanged in the market. Despite there being disagreement regarding the outcome being forecast, traders acted as if they were over-confident in the accuracy of their own private information. We find that the combination of these factors – differences across traders with respect to their private information and over-confidence born of the process of gaining private information – allowed those with an informational advantage to profit from their forecasting efforts.

These findings have implications for prediction markets in particular and financial markets in general. With respect to prediction markets, this study

confirms the conjecture that traders who bring valuable (i.e. accurate) information to a prediction market are rewarded for their participation. This is an important result since without the participation of informed traders, prediction market prices cannot be expected to communicate useful information to participants and observers alike.

With respect to financial markets, this study confirms the value of superior private information even in circumstances where traders can only know the accuracy of their private information *ex post*. At the same time, it must be noted that *all* traders in these markets generated their own private information. The process of creating a forecast and justifying it in writing appeared to create conditions favorable to over-confidence in one's private information. Therefore, while all traders sought to gain an informational advantage over others, only some actually succeeded. Furthermore, it seems that the very process of seeking an informational advantage over other traders provides the opportunity, through over-confident trading, for better informed traders to gain significantly superior returns.

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