Summer 2014

Essays in insider trading, informational efficiency, and asset pricing

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ESSAYS IN INSIDER TRADING, INFORMATIONAL EFFICIENCY, AND ASSET PRICING

by

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A thesis submitted in partial fulfillment
of the requirements for the Doctor of
Philosophy degree in Business Administration (Finance)
in the Graduate College of
The University of Iowa

August 2014

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CERTIFICATE OF APPROVAL

PH.D. THESIS

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To Mom, Pandora, Bouncer, Roger, Fedor, and Dr. Cox

ABSTRACT

In this dissertation, I consider a range of topics related to the role played by information in modern asset pricing theory. The primary research focus is twofold. First, I synthesize existing research in insider trading and seek to stimulate an expansion of the literature at the intersection of work in the insider trading and financial economics areas. Second, I present the case for using Peter Bossaerts' (2004) Efficiently Learning Markets (ELM) methodology to empirically test asset pricing models.

The first chapter traces the development of domestic and international insider trading regulations and explores the legal issues surrounding the proprietary nature of information in financial markets. I argue that, practically, the reinvigoration of the insider trading debate is unfortunate because, in spite of seemingly unending efforts to settle the debate, we are no closer to answering whether insider trading is even harmful, much less worthy of legal action. In doing so, I challenge the conventional wisdom of framing insider trading research as a quest for resolution to the debate. By adopting an agnostic perspective on the desirability of insider trading regulations, I am able to clearly identify nine issues in this area that are fruitful topics for future research.

The second chapter studies prices and returns for movie-specific Arrow-Debreu securities traded on the Iowa Electronic Markets. The payoffs to these securities are based on the movies' initial 4-week U.S. box office receipts. We employ a unique data set for which we have traders' pre-opening forecasts to provide the first direct test of Bossaerts' (2004) ELM hypothesis. We supplement the forecasts with estimated convergence rates to examine whether the prior forecast errors affect market price convergence. Our results support the ELM hypothesis. While significant deviations between initial forecasts and actual box-office outcomes exist, prices nonetheless evolve in accordance with efficient updating. Further, convergence rates appear independent of both the average initial forecast error and the level of disagreement in forecasts.

Lastly, the third chapter revisits the theoretical justifications for Bossaerts' (2004) ELM, with the goal of providing clear, intuitive proofs of the key results underlying the methodology. The seemingly biggest hurdle to garnering more widespread adoption of the ELM methodology is the confusion that surrounds the use of weighted modified returns when testing for rational asset pricing restrictions. I attack this hurdle by offering a transparent justification for this approach. I then establish how and why Bossaerts' results extend from the case of digital options to the more practically relevant class of all limited-liability securities, including equities. I conclude by showing that the ELM restrictions naturally lend themselves to estimation and testing of asset pricing models, using weighted modified returns, in a Generalized Method of Moments (GMM) framework.

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CHAPTER 1
INSIDER TRADING AND FINANCIAL ECONOMICS: WHERE DO WE GO FROM HERE?

Introduction

More than seventy years after the enactment of the first insider trading laws, insider trading remains one of the most controversial aspects of securities regulation. This is evidenced by the growing body of literature which questions whether insider trading is even harmful, much less worthy of legal action. However, the literature has stagnated to a degree, in that most new research merely adds to the debate within the conventional context. Therefore, I submit that it is time to synthesize the existing research, and then focus on expanding the literature. In fact, this chapter is my effort in leading insider trading scholars down this path of advancing the literature.

I contend that the time is ripe for just such an analysis. Recent insider trading-related events have captured the attention of both the academy and the public. Not only have celebrities (Martha Stewart and Mark Cuban) been accused of insider trading, but the Securities and Exchange Commission (SEC) has also been embarrassed by a scandal involving alleged insider trading by two of its own enforcement officers. Plus, as often happens when the economy is in shambles, there has been a lot of finger-pointing by politicians who seek a scapegoat for the current financial crisis. This environment, coupled with the populist perception that the alleged greed and misconduct of Wall Street professionals caused the "Great Recession," has emboldened the SEC in its enforcement activities.

I try to make four contributions to the insider trading literature. First, I provide an interdisciplinary synthesis of the existing literature. In the process, I do not limit my analysis to results from one particular country or research perspective. Second, I review the most important events that have transpired over the past several years. Third, I provide a novel treatment of the compilation and treatment of nine contemporary issues at the intersection of work in the insider trading and financial economics areas. In my discussion of these issues, I strive to bring some attention to new and exciting areas, such as prediction markets. Finally, I try to anticipate "the next big things" that will be of particular interest to insider trading scholars in the future, in the hope that these suggestions will motivate scholars to push beyond the current boundaries in the literature.

This chapter is organized in the following manner. The second section provides a historical overview of the relevant insider trading laws. The third section distinguishes between legal and illegal insider trading. The fourth section offers a discussion of recent events in the insider trading area. The fifth section reviews the literature regarding the issue of informativeness, and the sixth does the same for the issue of profitability. The seventh section outlines the insider trading debate and details the arguments for and against the criminalization of insider trading, including those regarding the effectiveness of regulations. The eighth section examines nine issues of particular interest to legal and financial scholars. I include an analysis of possible fruitful areas for future research within the discussion of the individual issues. Finally, the ninth section brings the chapter to its conclusion.

Laws

In response to the financial devastation wreaked by the Great Depression, the U.S. Congress passed the Securities Act of 1933 (SA 1933) (USC, 1933) and the Securities Exchange Act of 1934 (SEA 1934) (USC, 1934). The Securities Act was the first major federal legislation intended to regulate the sale of newly-issued securities. Before its passage, securities were regulated only by the states. The Exchange Act extended federal regulation of securities trading to securities that were already issued and outstanding. It also created the SEC, and charged it with regulating insider trading (USC, 1934). Consequently, the Exchange Act, its amendments, and additional legislation passed in subsequent decades—most notably, the Insider Trading Sanctions Act (ITSA) (Trader, 1984), the Insider Trading and Securities Fraud Enforcement Act (ITSFEA) (Trader, 1988), and Regulation Fair Disclosure (RFD) (USC, 2000), along with the case law interpretations thereof (for example, Cady, Roberts & Co., 40 S.E.C. 907, 912; SEC v. Texas Gulf Sulpher Co. (1969); Chiarella v. United States, (1980); United States v. O'Hagan, (1997)), formulate the legal bounds on insider trading. SEC enforcement officials have recourse to both criminal (USC, 1933, Sect 32 (a)) and civil (USC, 1933, Sec 21A) causes of action against those individuals that the agency suspects have committed insider trading.

Insider trading in the U.S. spiked in the late 1980s, highlighted by the mass indictments of Ivan Boesky and Dennis Levine (Stewart, 1992). In the age of cable television and international media outlets, these cases captured the attention of market regulators throughout the world, leading to widespread enactment of regulations throughout the 1990s (Bhattacharya & Daouk, 2002). By 1998, of the 103 countries that had stock markets, 87 had enacted insider trading laws and 38 had prosecuted at least one insider trading case; before 1990, the respective numbers were 34 and 9 (Stewart, 1992). Thus, while enforcement levels vary dramatically across countries, insider trading is, at least "on the books," an internationally-recognized problem. "[T]he existence and the enforcement of insider trading laws in stock markets is a phenomenon of the 1990s" (Stewart, 1992, p. 77). For further information, see Wang & Steinberg (2005).

Legal Insider Trading versus Illegal Insider Trading: A Distinction

Insider trading can be illegal or legal, depending on when the insider makes the trade and what is in the mind of the trader at the time of the trade. Illegal insider trading refers to the buying or selling of a security by an insider or a tippee, in violation of a fiduciary or other relationship of trust and confidence, while in possession of material, nonpublic information about the security (Newkirk & Robinson, 1998). The purpose of prohibiting such trading is to ensure that markets are fair by precluding trading by those who have special knowledge that is not available to other traders (Clark, 2010). Insider trading is legal once the material information has been made public, at which time the insider has no direct advantage over other investors. The SEC, however, still requires that insiders report all of their transactions. This policy distinction allows insiders to trade their own securities for legitimate purposes, such as to diversify their holdings.

In practice, illegal insider trading is an extraordinarily difficult crime to prove. First, it can be hard to determine what the accused actually knew at the time the trades were made. Second, it can be challenging to establish that a particular individual was responsible for a trade, because knowledgeable traders can "hide behind" a variety of proxies and complete their trades over a number of international markets, many of which do not cooperate with the authorities. Third, wealthy insiders can afford to retain distinguished attorneys who can "drag out" cases at significant cost to the U.S. taxpayer. Fourth, direct evidence of insider trading is rare. Unless the defendant confesses or the prosecutor has access to testimony from an eyewitness whistleblower, cases are almost entirely circumstantial. Fifth, burgeoning swaps and options markets afford insiders more sophisticated tools for avoiding detection. Finally, the details of insider trading cases can be difficult to grasp by non-experts, thereby making it more difficult for prosecutors to convince juries that an actionable crime has been committed.

Recent Developments: A Renewed Interest

The financial scandals of the early 2000s and the current meltdown on Wall Street have revived the SEC's interest in insider trading. This has caused a concurrent stimulation of academic and legal research in this area.

Insider trading was not commonly prosecuted until the second half of the 20th century. Between 1966 and 1980, the SEC only filed an average of 2.6 cases per year, while between 1982 and 1986, it filed an average of 17.2 cases per year (Seyhun, 1992). After the spike in insider trading in the late 1980s, highlighted by the indictments of Boesky and Levine, there were no insider trading prosecutions of Wall Street professionals by the SEC between 1990 and 1995, and only ten such prosecutions between 1995 and 2000 (Thomsen, 2006). Insider trading actions have been much more prevalent in this first decade of the 21st century. The SEC had 106 successful insider trading convictions between 2001 and 2006. In the first half of the year 2007 alone, the SEC brought enforcement actions against over 20 defendants for insider trading, most of which involved insider trading in advance of mergers and acquisitions (Gorman, 2007).

There have been a number of interesting and important legal developments in the insider trading area in the last few years. First, the SEC has broadened the liability of employers for employee actions (SEC, 2006). Second, the agency not only publicly announced (Thomsen, 2006) that it was prioritizing hedge fund insider trading, but it also proceeded to back up (Thomsen, 2008) this commitment. In 2009, three particularly significant hedge fund-related cases were brought within a three-week period, including the largest such case in the agency's history (Clark, 2010). This focus on hedge funds was also evident in Europe (Financial Services authority (FSA), 2005). Third, the SEC announced that an agreement had been reached among the major securities self-regulatory organizations to centralize insider trading regulation (SEC, 2008). Prior to this announcement, each equity exchange was responsible for surveillance of trading on its market and any investigations and enforcement actions involving its members. This centralization of surveillance should improve detection of insider trading across the equities markets by focusing expertise and eliminating gaps and duplication among the markets.

Fourth, the SEC announced a policy designed to encourage individuals to cooperate with the agency in its insider trading investigations (SEC, 2010). Fifth, the agency tried to expand the scope of insider trading law in the first case to allege insider trading in credit default swaps (CDS) (Clark, 2010). While the case has yet to be decided, the court refused to dismiss the case (Weidlich, 2009) on the grounds that it was an issue of fact, not law, as to whether the CDS met the definition of security under existing insider trading laws (McGrath, 1993). It is not surprising that the SEC would try to extend its reach to CDS because most CDS are bought and sold in privately negotiated deals, so they are not exposed to a market surveillance system or a central database of transactions (Drummond, 2007). The SEC also successfully expanded the scope of insider trading law by extending the theories under which it may pursue insider trading (Clark, 2010).

Sixth, just as the Martha Stewart insider trading scandal was starting to fade from the public's mind, the SEC brought insider trading charges against another celebrity—Mark Cuban (Clark, 2010). The case was interesting beyond Cuban's public persona, though, because the basis on which the SEC charged Cuban had never been used before. Thus, the case also represented an attempt by the SEC to stretch its authority beyond its present scope. The SEC alleged that Cuban committed insider trading by violating an oral agreement that he allegedly made to keep sensitive information about Mamma.com's upcoming private offering confidential (Clark, 2010). Cuban's lawyers, as well as five respected law professors who filed a brief in support of Cuban's position, argued that Cuban, whose shares represented a 6.3% stake in the firm, was never an "insider" because he did not have a fiduciary duty in his relationship with the company (Michaels & Case, 2009).

A federal court sided with Cuban and rejected the SEC's complaint on the grounds that the agency had not proved that Cuban had a legal responsibility not to trade based on the information (Goldfarb, 2009). In other words, since Cuban was just an ordinary shareholder and the SEC could not prove that any promise was made not to trade on the disclosed information, he did not have the fiduciary duty required to establish illegal insider trading. While the SEC has appealed this decision, Cuban, who has deep pockets, has vowed to fight. Hence, the agency seems to be facing an uphill battle in establishing this novel application of the insider trading laws.

Given the increased attention that the agency has devoted to insider trading, the SEC was majorly embarrassed when its own insider trading scandal was exposed last year (Scannell, 2009). Based on multiple reported cases of suspicious trading, the SEC's inspector general concluded that two SEC employees had violated the agency's internal rules. Thus, the inspector general recommended disciplinary action against the two employees, who both continue to work for the SEC, and referred the case to the U.S. Attorney's office and the FBI (Scannell, 2009). However, no criminal charges have been filed against the individuals.

Given the embarrassment caused by this incident, on May 22, 2009, SEC Chairman Mary Schapiro announced steps that the agency was taking to strengthen existing rules governing securities trading by personnel (Scannell, 2009). In particular, the SEC was responding to the claim in the aforementioned inspector general's report that the SEC has "essentially no compliance system" to detect potential insider trading (Scannell, 2009). Ironically, one could argue that the lack of oversight by the SEC would give the SEC grounds for bringing insider trading charges against itself in a manner similar to that described above when the agency settled with Morgan Stanley in 2006.

The uptick in insider trading surveillance and prosecution has not been confined to the U.S. For instance, in 2003, the European Union (EU) enacted the Market Abuse Directive to combat insider trading within the region (European Parliament, 2003). The implementation of this Directive has led to increased vigilance in the member states (Gasteen, 2010). From 2009 to the end of March in 2010, at least six other countries (Australia (Murdoch, 2009), Canada (Bessner & Graham, 2010), Italy (Sherer & Martinuzzi, 2010), United Kingdom (Binham, 2010), China (Collins, 2010), and Kenya (Anyanzwa, 2010)) across five continents have reported increased levels of insider trading enforcement. Therefore, I can safely conclude that insider trading remains a focus of international attention.

Informativeness

Numerous studies have examined whether insider trades are informative. The issue is interesting beyond the insider trading context because it relates to the extent of efficiency in a market. More specifically, if insider trades are informative, then markets are not strong-form efficient.

One set of studies examines the relationship between the information contained in earnings announcements and that revealed by the trades of insiders. For instance, Penman viewed insider trading as a signal of managements' assessments of firms' future prospects, and compares the information content of these trades to that in managements' earnings forecasts (Penman, 1985). He found that the insider trading measures that account for the timing of the trades relative to the release date of the forecast are informative (See also Allen & Ramanan (1995)).

A similar set of studies analyzes the relationship between the information contained in a variety of other corporate announcements and that revealed by insider trades. In an examination of corporate sell-offs, Hirschey and Zaima (1989) found that insider trading and ownership structure information were used by the market in the classification of sell-off decisions as favorable or unfavorable for investors. Thus, they concluded that this voluntary announcement was informative. Similar results have been found for the informational role of corporate dividend announcements (John & Lang, 1991).

A final set of studies in this area concerns the predictive content of insider trades for outsiders who seek to secure abnormal returns by mimicking these trades. Givoly and Palmon (1985) established that the abnormal returns gained by insiders could be largely due to price changes arising from the disclosure of the trade itself, rather than to subsequent disclosure of specific news about the company to which the insiders might be privy. Other authors have confirmed that outsiders can garner abnormal returns by using publicly reported insider trading data as a leading indicator (Rozeff & Zaman, 1988). This implies that the mere occurrence of insider trading, whether or not it is information-based, may generate abnormal returns. Hence, it is not surprising that many business magazines report information on individual- and aggregate-level insider trading.

However, Seyhun (1992) provided evidence that the abnormal returns were actually due to the informativeness of the trades by documenting that, from 1975 to 1989, aggregate insider trading predicted stock returns. In particular, the aggregate net number of open market purchases and sales by insiders in their firms predicted up to 60% of the variation in one-year-ahead aggregate stock returns (Seyhun, 1992). Lakonishok and Lee (2001) extended the results through 1995 and indicated that the results were driven by insiders' abilities to predict the returns of smaller firms. These results have also been found to hold in the United Kingdom (U.K.), where insider trades are even more informative than those in the U.S (Fidrmuc, 2006). Adding robustness to these findings is the fact that trades by insiders in options markets have also been shown to be information-based (Chen & Zhao, 2005).

I did find one study that surmised that insider trades were not informative (Chakravarty & McConnell, 1999). However, the persuasive power of this study is limited by the fact that one of the co-authors later co-authored a paper that argued in favor of there being an important informational role for options (Chakravarty, Gulen, & Mayhew, 2004). Thus, given the results discussed above from all three sets of informativeness studies, the evidence in support of the contention that insiders' trades are information-based is quite compelling.

Profitability

Given that insiders' trades are informative, is it also clear that they are abnormally profitable? This is a key question because if insiders do not, on average, earn abnormal returns (inflation-adjusted returns in excess of the return that the average investor could have expected to earn on a similar trade involving a firm with the same level of systematic risk) on their trades, then one could offer three compelling reasons that regulators should not concern themselves with such activities: (1) if, in expectation, insiders cannot profitably exploit their information, then they would no longer have an incentive to engage in such trading; (2) there would be no increased likelihood of "harm" because counterparties to insider trades would not be any more likely to lose money on their average trades; and (3) the information conveyed by the trades would tend to improve market efficiency. Studies of abnormal profitability involve the event study methodology. Therefore, a finding of abnormal profitability is conditional on the model used by the researcher to calculate expected returns being correctly specified. Also, for parametric model-based estimators other than Generalized Method of Moments estimators (that only yield asymptotically valid inferences), the results are conditional on the correct specification of the data generating process for the employed test statistics. Consequently, the results of these studies should be scrutinized for possible violations of the following assumptions: (1) normality of the prediction errors; (2) contemporaneous correlation in the prediction errors; (3) serial correlation in the prediction errors; (4) parameter stability in the estimates; (5) no event-induced volatility changes; (6) homoscedasticity of the prediction errors; and (6) use of prediction errors, not residuals. Hence, I will now examine whether insiders are, in fact, able to profit from their information-based trades.

In all of my research, I uncovered just one study that contradicted the widespread belief that insiders in the U.S. markets are able to secure statistically significant abnormal profits (Aktas, De Bodt, & Van Oppens, 2008). The remaining evidence overwhelmingly supports the notion that, on average, insider trading in the U.S. is a profitable activity (Seyhun, 1986; Meulbroek, 1992; and Jeng, Metrick, & Zeckhauser, 2003). These results are robust across a number of different event definitions and trading scenarios in that the sign, but not necessarily the magnitude, of the average abnormal return accruing to insiders has been confirmed in myriad other studies (Lorie & Niederhoffer, 1968; Keown & Pinkerton , 1981; Netter & Mitchell, 1989; Lin & Howe, 1990; Cornell & Sirri, 1992; Damodaran & Liu, 1993; Sivakumar & Waymire, 1994; or Noe 1999).

Despite the compelling evidence of profitability in the U.S., results from other countries are mixed. Profitability has been established for markets in Canada (Baesel &

Stein, 1979), the Netherlands (Biesta, Doeswijk, & Donker, 2003), the U.K. (Biesta, Doeswijk, & Donker, 2003), Italy (Bajo & Petracci, 2006), and South Africa (Opoku, 2007). Conversely, insider trades have been shown to be unprofitable, on average, in Norway (Eckbo & Smith, 1998) and Hong Kong (Wong, Tan, & Tian, 2009).

The Insider Trading Debate

Arguments for Regulation

Since the publication of Henry Manne's seminal work, *Insider Trading and the Stock Market* (1966), scholars have debated whether insider trading should even be regulated. A number of moral and economic arguments have been advanced for prohibiting this practice: (1) insider trading is a fraudulent business practice that exploits non-insiders; (2) the insider-investor relationship creates a fiduciary duty that insiders would violate by engaging in insider trading; and (3) allowing insider trading would tarnish the information access associated with the aggregate effect of trading on the market because insiders possess special information as a result of their work product (e.g. Hu & Noe, 1997). The first of these arguments is a moral one, while the other two arguments are economics-based. Moral arguments are subjective, citing issues of "fairness" as the basis for prohibiting insider trading. The economic arguments are objective, in that they dictate that insider trading should be prohibited because the market-related benefits of doing so are greater than the associated costs of such regulation. Since moral arguments are inherently debatable, and this paper is not philosophical in nature, I will focus on the economic arguments made by proponents of regulation.

One economic argument for regulating insider trading is that the prohibitions are needed to incentivize information traders to collect and analyze information (Grossman & Stiglitz, 1980). This line of argument posits that insider trading regulations exist to safeguard information traders from competition from insiders, so that insiders do not undermine the ability of information traders to recoup their investments made to collect and analyze information (Khanna, 1997). Proponents suggest that this is the optimal arrangement because information traders can best underwrite efficient and liquid capital markets (Goshen & Parchomovsky, 2006). In other words, governments should regulate markets to protect information traders, not general shareholders.

Another economic argument for regulation is that outsiders will lose confidence in the market and refuse to participate when insiders are able to use material non-public information to secure abnormal profits in their trades with outsiders (Jalil, 2003). In turn, this would lead to decreased liquidity and an associated increased cost of capital (e.g. O'Hara, 1998). The implication is that insider trading should be regulated because corporate investment is discouraged when insiders are allowed to use private information to appropriate some part of the returns to corporate investments made at the expense of other shareholders (Manove, 1989).

Underlying both core arguments for regulation is the belief that insider trading should be restricted because it makes markets less than perfectly competitive, thereby impeding stock price efficiency. The two arguments differ with respect to the parties that they ostensibly seek to protect—information traders or shareholders (e.g. Fishman & Hagerty, 1992).

Arguments against Regulation

Prior to the publication of Manne's (1966) groundbreaking analysis, the pro-regulation arguments went virtually unchallenged. However, Manne's anti-regulation arguments quickly gained traction, especially among the "the law and economics" scholars of the University of Chicago (Bainbridge, 2008). Manne explicated two key principles that he felt should guide all analyses of insider trading: (1) insider trading should be a contractual, rather than a criminal matter; and (2) shareholders, as a whole, are not hurt by insider trading (Manne, 1966).

Based on these theoretical constructs, Manne (1966) proffered two influential arguments for deregulating insider trading. The first is that trading by insiders allows information to be rapidly impounded in the prices of securities, thereby increasing the efficiency of capital markets (Manne, 1966). For instance, he argued that the financial scandals of the early 2000s would never have erupted if insider trading had been allowed (Manne, 2005). His reasoning is that there would have been plenty of people inside those corporations who would know what was happening. Most likely they would have succumbed to the temptation of getting rich by trading on the information. In the process, the stock market would have reflected the problems months earlier than it did under the current system (Dinehart, 1986).

Manne's second anti-regulation argument was that security trading improved the alignment of interests between outside claimants and management by allowing managers to profit from the appreciation in firm value that their efforts stimulated (Manne, 1966). Accordingly, insider trading can serve as an efficient compensation scheme for managers. This type of behavior is particularly useful for incentivizing entrepreneurial activities because it encourages managers to take risks in the pursuit of innovation (Manne, 2005). Such compensation schemes directly benefit shareholders because firms can pay lower salaries without sacrificing innovative behavior.

The treatment of insider trading as a contractual issue dovetailed nicely with the theories that secured a Nobel Prize for another law and economics scholar, Ronald Coase. Coase argued that contracting parties, absent transactions costs, will reach a Pareto efficient allocation of property rights (Coase, 1937). Consequently, numerous scholars, most of whom are proponents of Manne's anti-regulation theories, have brought Coases's insight to bear on the insider trading debate. I will develop this in more detail later in the paper. Moreover, the Coase Theorem has proved highly influential in legal analysis in general (Coase, 1960). For instance, these ideas have served as the foundation for arguments against regulation made by both agency theorists and proponents of competition through self-regulation (Carlton & Fischel, 1983).

The self-regulation theorists do not necessarily claim that insider trading should not be regulated; rather, they contend that insider trading can be effectively barred by contract, if the shareholders of a particular firm desire such a ban (Fisher, 1992). The implication is that, even if shareholders perceive that the costs of insider trading outweigh the benefits, issuers with shareholder consent, should be the ones to make the regulatory decision, not external regulators (Haddock & Macey, 1986). A similar argument notes that even if insider trading cannot be handled by contract and even if the SEC is the best alternative prohibitive mechanism, then firms should still be able to "opt out" of the SEC's ban (Painter, 1999). Consequently, if insider trading regulation was intended to benefit ordinary shareholders, then the current laws could remain largely intact, while permitting corporations to opt out of its restrictions if they chose to do so. The work in this area has started to merge with that of the Coasian optimal contracting theorists (e.g., Macey & O'Hara, 2005). A related argument is that by permitting exchanges to regulate themselves, the government would ensure that the exchanges compete for trading volume, as they have better incentives to regulate themselves than does the government. The resulting self-instituted regulations would encourage investor participation while retaining the powerful incentive provided by competition.

Analyzing the Arguments

Given the divergent claims made by the pro- and anti-regulation camps, it is not surprising that the authors in these areas continue to publish papers in which they challenge the insights of the opposing theorists. I will now review the major arguments that have emerged in this ongoing debate.

Some authors have claimed that Manne's arguments are based on a misunderstanding of economics (Klock, 1994). These proponents of regulation claim that economic theory and evidence actually favor prohibition on insider trading as a matter of "efficiency." Several authors even structure their papers so as to entertain each of Manne's arguments in turn, and then point out alleged flaws with the reasoning (Dyer, 1992; Prentice & Donelson, 2010). However, these arguments have not gained much traction in the literature, as most insider trading scholars do not dispute Manne's economic reasoning (Bernhardt, Hollifield, & Hughson, 1995; Boudreaux, 2009; Carney, 1998; Fisch, 1991; Harris, 2003; Winter, 1988; Zekos, 2005). This is not meant to imply that the majority of economists favor deregulation. To the contrary, 77.6% of surveyed economists stated that insider trading should be regulated, yet few of these economists challenge the logic of Manne's analysis (Padilla & Gardiner, 2009).

Recall from the discussion of "Informativeness" that the pro-regulation scholars claim that insider trading makes stock prices less efficient because it leads to "unequal access" to information, thereby limiting the competition in the market (Ausubel, 1990). However, the anti-regulation scholars seem to be carrying the day on this issue because, as discussed above, most studies indicate that insider trades are informative, and there does not seem to be a significant countervailing reduction in liquidity due to decreased participation (Cao, Field, & Hanka, 2004). I will analyze liquidity in much more detail later in the specific issues section of the paper.

Another element of the debate concerns the validity of Manne's (1966) assertion that, in the aggregate, investors are not harmed by insider trading. Anti-regulation scholars have provided evidence that supports this claim (Achary & Johnson, 2007; Estrada, 1995; Macey, 1988; Manne, 1970). However, several pro-regulation scholars have countered that insider trading is not a "victimless crime" (Douglas, 1988). For instance, they suggest that outside investors and liquidity traders are hurt at the expense of insiders (Copeland & Galai, 1983).

Political economists have also engaged in the insider trading debate. These scholars have a different perspective regarding insider trading "harm." More specifically, many of these researchers adopt a private interest approach to insider trading (Tighe & Michener, 1994). In other words, they argue that insider trading laws serve private, not public interests, so that ordinary shareholders ("the public") derive no benefit from such regulations. Conversely, market professionals can profit substantially from the ban of insider trading, so they marshal their resources and lobby lawmakers to pass such regulations that are in their interest (Haddock, 1999). Thus, political economists accept that the public is going to "lose," on average, with or without insider trading (Haddock & Macey, 1987). The only relevant question is who will be the average "winner" on the other side of the transactions—an information analyst or a corporate insider (Beny, 2008)? The implication is that the insider trading debate should focus on which allocation (insider or analyst) is Pareto optimal, not on whether insider trading harms "the public." The evidence on this issue is mixed (Ayres & Choi, 2002 or Shin, 1996).

Legislative Effectiveness

As the preceding discussion indicates, no resolution has been reached regarding the desirability of insider trading regulations. I will now consider, regardless of whether the regulations are necessary, if enforcement actions brought under existing regulations are effective.

While some empirical (Agrawal & Jaffe, 1995; John & Narayanan, 1997; Carpenter & Remmers, 2001) and theoretical (Huddart, Hughes, & Williams, 2004) studies of existing legislation indicate that enforcement actions effectively deter managers from engaging in illegal insider trading (Cox & Fogarty, 1988), the support for the position that these actions are not effective is more ample. First, the SEC's effectiveness in general has been called into question for its oversight of investment banks that collapsed and its failure to detect the multibillion dollar investment fraud pulled off by money manager Bernard Madoff (Coffee & Sale, 2009; Fisch, 2009; McGunty & Scannell, 2009). Second, the SEC readily admits that insider trading cases are very difficult to prove (Thomsen, 2006). Third, the effectiveness of insider trading laws is limited by the fact that the body of law in this area is very confusing, even to experts (Acoba, 1999; Aldave. 1984; Anabtawi, 1989; Heminway, 2003; Langevoort & Gulati, 2004; Prakash, 1999; Thel, 1997). Fourth, as established in the "Profitability" section above, outsiders can often secure abnormal profits by "mimicking" the legally reported trades of insiders. This suggests that insider trades are information-based. Fifth, U.S.-based empirical studies indicate that not only do insider trading enforcement actions lack a significant deterrent effect, but they may also have the opposite effect (Banerjee & Eckard, 2001; Bettis, Coles, & Lemmon, 2000; Fishman & Hagerty, 1995; Jaffe, 1974; Ke, Huddart, & Petroni, 2003; Pettit, Ma, & He, 1996). However, results from non-U.S. markets have been mixed—regulation has been found to be effective in New Zealand (Gilbert, Tourani-Rad, & Wisniewski, 2007), but ineffective in Canada (McNally & Smith, 2003) and the EU (Hostetter, 1999).

In summary, there are a lot of supporters on both sides of the insider trading debate, so the issue is not likely to be resolved in the near future. In the meantime, the practical reality seems to be that insider trading regulation is here to stay. Therefore, for the remainder of this paper, I will take the existence of such regulations as a given, and discuss their economic implications.

Nine Issues

Issue 1: Distinguishing between Positive and Negative Information

The standard justifications for regulating insider trading ignore the fact that there are two distinct types of insider trading: insider trading based upon positive information and insider trading based upon negative information. Positive information (price-increasing insider trading) is non-whistleblower information, while negative information (price-decreasing information) is essentially a whistleblower's facts made known. This distinction is relevant for the insider trading debate, but it has not received much attention in the literature. In other words, most scholars assume, at least implicitly, that price-decreasing insider trading and price-increasing insider trading should be handled in an equivalent fashion—either both should be regulated or neither should.

Nonetheless, a few researchers have recognized the crucial distinction between trading on positive insider information and trading on negative insider information, and explored the attractiveness of an asymmetric insider trading regime—one that continued to regulate price-increasing insider trading in the conventional manner, yet offered no (or less stringent) regulation of price-decreasing information. These asymmetric regimes typically involve an analysis of what bargain would be reached if shareholders and insiders were practically and legally able to negotiate with respect to the insider trading rights in the firm. The goal is to see whether the resulting insider trading regulation would be asymmetric, and the existing regime would only be maintained if this was not the case.

Lambert (2006) offered a particularly lucid explanation of the asymmetric approach to insider trading regulation. He argued that affording different legal treatment to the two types of trading was justified by the fact that price-decreasing insider trading provides significantly more value to investors than did price-increasing insider trading. The signaling effect of price-decreasing trades would be amplified by requiring public announcement of these trades immediately upon execution, because executives would be less able to "game" the system through strategic trading. Lambert argued that, under such a system—one where insiders could make price-decreasing trades so long as they immediately announced the trades to the public—most negotiations would result in the adoption of asymmetric regimes. Hence, he concluded that regulators should establish such a policy as the default that would govern in the absence of express contracting (Lambert, 2006).

Grechenig (2006) verified the optimality of an asymmetric insider trading regime. Such a regime would deter corporate malfeasance because insider trading on negative information discloses concealed information to the market in a manner functionally equivalent to whistleblowing. Furthermore, existing studies tend to indicate that important gains to social welfare come with insider trading on negative information (sales), whereas losses frequently result from the use of positive information (purchases). These arguments prompted Grechenig to appeal to regulators to adopt an approach that would allow insiders to trade based on private price-decreasing information (Grechenig, 2006).

While this is a relatively new topic in the insider trading debate, existing research tends to support an asymmetric approach to insider trading regulation. In particular, the studies indicate that social welfare would be enhanced if regulators allowed insiders to trade based on negative private information (price-decreasing trades). Accordingly, the results in this section provide a measure of "victory" for the anti- and self-regulation schools of thought.

Issue 2: Law and Finance

Law and finance scholars use cross-country empirical evidence to relate the development of a country's capital markets with the laws, regulations, and enforcement policies of that country. The early studies in this area spawned the legal origins theory of capital development (López de Silanes, La Porta, Shleifer, & Vishny, 1998). Legal origins scholars suggest that, relative to private enforcement, public enforcement of securities obligations is of limited value (Porta, Lopez-de-Silanes, & Shleifer, 2006). Confirmatory results have been found with respect to both liquidity and trading costs (Eleswarapu & Venkataraman, 2006; Li, Moshirian, Pham, & Zein, 2006).

However, these assertions have not gone unchallenged. Numerous scholars have argued that governments seeking to develop their stock markets so as to facilitate investment should implement stricter insider trading laws and enforcements. The most famous of these studies was conducted by Bhattacharya and Daouk who found that, while the cost of equity in a country does not change after the introduction of insider trading laws, it does significantly decrease after the first insider trading enforcement action (Ackerman, & Maug, 2006; Bhattacharya & Daouk, 2002). In a complementary study, Beny (2005) empirically verified the existence of a positive correlation between the level of a country's stock market development and the stringency of its insider trading laws and enforcement. Opponents of the legal origins theory have also contested the assertion that public enforcement of securities laws is not particularly effective (Bushman, Piotroski, & Smith, 2005; Du & Wei, 2004; Frijns, Gilbert, & Tourani-Rad, 2010; Halling, Pagano, Randl, & Zechner, 2008).

In summary, the bulk of the law and finance literature tends to indicate that equity costs are lower in countries that have and enforce insider trading regulations than they are in countries that do not take such actions. That being said, while the correlation seems robust, it is not clear that it is the existence or enforcement of the regulations that is causing the lower equity costs. Consequently, I expect law and finance to maintain its status as an active area of research for legal origins theorists and their opponents.

Issue 3: Corporate Governance

An area of research that is closely related to the law and finance literature is that of corporate governance. While law and finance researchers focus on country-level determinants of financial development, corporate governance scholars examine firm-level determinants of financial development (Becht, Bolton, & Röell, 2003; Maug 2002). Insider trading is a focus of firms' corporate governance efforts, as evidenced by the fact that company-level regulation of insider trading is widespread (Bettis et al., 2000). Thus, it is not surprising that several papers have also analyzed the role of insider trading regulations in the corporate governance area (Bushman & Smith, 2003).

Theoretical analysis of the impact of insider trading regulation on corporate governance has shown that managers of corporations which have large, dominant shareholders who can monitor the firm have an incentive to give early warnings about negative developments to these dominant shareholders (Maug, 1998). Essentially, the manager is bribing the dominant shareholders to get them to sell their shares instead of intervening. Consequently, pro-regulation scholars have argued that, if insider trading is not regulated, then dominant shareholders will collude with management, to the detriment of small shareholders (Maug, 1998).

Self-imposed governance by firms has been shown to be effective. For instance, firms that voluntarily adopt blackout periods have narrower bid-ask spreads (spreads) (Bettis et al., 2000). Furthermore, trades made during the allowed windows are only slightly more profitable than those made during prohibited blackout periods (Bettis et al., 2000). These results have been extended to the case of firms that regulate insider trading via general corporate governance policies—beyond blackout periods. Insiders in these firms have also been shown to secure significantly lower abnormal returns than do insiders in firms without such policies (Bettis et al., 2000). Subsequent studies have verified that a firm's general counsel—the executive whose primary responsibility is to monitor corporate governance within the firm—can play a significant role in restricting insider trading by corporate officers (Jagolinzer, Larcker, & Taylor, 2011). Theoretical studies indicate that, by adopting corporate governance policies that regulate insider trading activity by insiders, firms can decrease their cost of capital (Easley & O'Hara, 2004). Recent empirical analyses have confirmed these results for both the U.S (Ravina & Sapienta, 2010; Rozanov, 2008) and Canada (Anand & Beny, 2008).

Multiple studies have used international data to more directly examine the link between insider trading regulations and corporate governance. Results indicate that, although stricter insider trading regulation reduces private information trading, the laws become more effective for corporations with poorer quality corporate governance (Durney & Nain, 2005). This makes intuitive sense when one considers that managers who divert firms' resources will attempt to mask the resulting poor performance of the firm. This will obviously foster information asymmetry, and in the process, increase the returns to private information trading. The implication is that the quality of information provided to the public declines when strict insider trading restrictions are imposed on firms with inferior governance (Durney & Nain, 2007). As such, imposing insider trading restrictions on firms with governance problems or in countries where investors are not protected sufficiently may actually increase private information trading (Durney & Nain, 2007). Hence, these papers call into question the wisdom of introducing and enforcing insider trading restrictions in countries where firms have low-quality corporate governance.

Pro-regulation scholars are probably encouraged by the results discussed in this section. Existing evidence indicates that, in both the U.S. and Canada, firms can use corporate governance mechanisms to limit the ability of insiders to profit from their inside information. That being said, Coasians and self-regulators may also be encouraged by these results because they are achieved via private contract on a firm-level basis. In fact, this reasoning led Manne to introduce a corporate governance dimension to the insider trading debate (Manne, 2005).

Issue 4: Agency Issues and Managerial "Gaming"

At the firm level, the insider trading debate centers on the impact that insider trading has on the intra-firm agency conflict between the agents (insiders) and the principals (non-controlling shareholders). A substantial body of research has been devoted to examining whether insider trading makes this conflict better or worse. This issue is germane to the policy question about whether insider trading should be regulated (if at all) at the market-level, by the government, or at the firm-level, via contract. The two major views in this area reflect the underlying tension between the anti-regulation and pro-regulation scholars in the insider trading debate. Anti-regulation scholars assert that regulations decrease social welfare because insider trading mitigates the intra-firm agency conflict (Carlton & Fischel, 1983). Conversely, pro-regulation researchers contend that regulations are welfare increasing, on the grounds that insider trading exacerbates the intra-firm agency conflict (Cox, 1986).

Karpoff and Lee (1991) paved the way for the empirical analysis of agency issues surrounding insider trading by examining trades made by insiders before the insiders' firms announced their plans to issue new securities. The authors hypothesized that, if the expected cost of insider trading is sufficiently high, then no unusual trading will occur before new issue announcements. However, they found that, on average, insiders were still making abnormally large trades in their securities prior to new issue announcements. As such, they concluded that the expected benefits from insider trading still outweighed the expected costs (Karpoff & Lee, 1991). These results indicate that managers continue to try to "game" the system by making information-based trades. Myriad studies have confirmed Karpoff and Lee's results for other market events, including spinoffs (Allen, 2001), leveraged buyouts (LBOs) (Harlow & Howe, 1993), bankruptcies (Seyhun & Bradley, 1997), takeovers (Muelbroek & Hart, 1997), securities class action (SCA) suits (NeHaus & Roth, 1999; Peng & Roell, 2008), repurchases (Fried, 2000), mergers (Fich, Cai, & Tran, 2011), and spending by managers to improve investor relations (Hong & Huang, 2005).

A related stream of research from the accounting literature examines the relationship between managers' public dissemination of information about the firm and insider trading in the firm's shares by those managers. For instance, Penman (1982) found that insiders secured abnormal returns by strategically timing their trades relative to the date of annual earnings forecast announcements. Baiman and Verrecchia (1996) confirmed that increased disclosure reduced managers' insider trading profits, while increasing the residual moral hazard problem. Similarly, Beneish and Vargus (2002) found that insider trading was an informative signal about earnings quality and the valuation implications of accruals. These results suggest that an agency conflict results from insiders' ability to exploit their superior knowledge of the economic factors underlying the persistence of their firms' income-increasing accruals.

Many studies in the agency conflicts literature overlap significantly with those that analyze regulatory effectiveness. Choi (2002) proffered that selective disclosures may actually provide a number of benefits to all shareholders of a corporation. For instance, they may help subsidize analysts that otherwise would not cover the disclosing firm. However, he acknowledged that selective disclosures were a source of agency conflicts because managers could use them for their own opportunistic endeavors (Choi, 2002). Nonetheless, Choi (2002) argued that RFD is an overly broad response to the risk of opportunism that reduces shareholder welfare by preventing beneficial, as well as harmful, selective disclosures (Brunnmeier, 2005).

Similarly, Billings (2008) investigated whether managers' disclosure delays related to the opportunity to decrease their equity positions in their firms and, if so, whether this trading led to increased litigation consequences. He found that managers who were less timely in their disclosure of negative news were more likely to have engaged in abnormal trades prior to the market's receipt of the negative news. Moreover, this trading behavior is associated with increased litigation consequences for the firm (Billings, 2008). This provides additional evidence for the existence of agency conflicts between insiders and shareholders (Jagolinzer & Roulstone, 2007).

Insider trading has also been empirically linked to the financial and accounting scandals that occurred in the early part of this decade. For instance, Agrawal and Cooper (2008) theorized that managers would be less likely to trade before accounting scandals than before other major corporate events, such as takeovers or bankruptcies, because managers who sell stock while earnings are misstated risk being charged with both insider trading, and the separate crime of earnings manipulation. As a result, such selling by insiders increases investor scrutiny and the likelihood of the manipulation being discovered. Surprisingly, the authors found strong evidence that managers of restating firms sell substantially more stock during the misstated period. These results suggest that managers' desires to sell their shares at artificially inflated prices motivate them to manipulate earnings. Hence, Agrawal and Cooper concluded that, since insiders brazenly commit these crimes, illegal insider trading is probably more widespread in the market than has been found in the prior literature (Agrawal & Cooper, 2008).

Other connections have been made in the literature between law and finance research and agency conflicts research. In a recent study, Beny (2008) modeled insider trading as an agency problem in firms that have a large, controlling shareholder, and examined firm-level, cross-sectional data from twenty-seven developed countries to identify the relationship between corporate value and insider trading laws among such firms. Her empirical results suggest that insider trading laws are able to mitigate agency costs in common law countries, but not in civil law countries. In neither case, however, does Beny find evidence in support of the claim that insider trading laws exacerbate agency costs. Consequently, she challenged the assertions made by the school of agency theorists who argue for the deregulation of insider trading (Beny, 2008).

The studies reviewed in this section provide strong evidence that, even in the presence of insider regulations, managers can and do extract rents at the expense of shareholders. On the one hand, anti-regulation researchers could say that, as these results tend to confirm that insider trading regulations are ineffective, the costs of such regulations outweigh their benefits. On the other hand, pro-regulation scholars could contend that agency problems would be even more severe in the absence of insider trading regulations.

Issue 5: Executive Compensation

Manne (2005) made a second argument for the deregulation of insider trading that has also proved influential, especially to agency theorists. In particular, he claimed that the deregulation of insider trading would allow firms to pay managers lower salaries, because the managers could secure additional compensation by profiting from trades based on their private information. In an influential study, Carlton and Fischel (1983) adopted a Coasian, optimal contracting approach to provide support for Manne's position. (See Mark Gillen (2006) for an overview of the empirical evidence on insider trading and executive compensation.)

A number of studies have provided empirical support for the anti-regulation approach to insider trading and executive compensation. For instance, Roulstone (2003) documented that firms with internal restrictions on insider trading during certain times, such as periods before and after earnings announcements, paid an executive compensation premium of between 4% and 15% over firms that did not have such internal insider trading restrictions. This apparent empirical connection between the prohibition of insider trading and higher forms of other compensation prompted Roulstone (2003) to conclude that, whatever other benefits the prohibition of insider trading might provide, they must be sufficient to compensate for the increased executive compensation (See also Gayle & Miller, 2009; Hu & Noe, 1997; Narayanan, 1999).

Even otherwise pro-regulation scholars have found empirical results that support Manne's position on executive compensation. For instance, on the grounds that increased volatility of outcomes would enable insiders—who learn of outcomes in advance of the market—to make greater trading profits, Bebchuk and Fershtman (1994) hypothesized that, all else being equal, insider trading would lead insiders to choose riskier projects. The authors verified this hypothesis, and argued that this effect can actually be socially beneficial, because the fact that insiders are risk averse tends to lead them to adopt more conservative investment policies (Bebchuk & Fershtman, 1994; Bernardo, 2001). This is interesting because it is in line with recent papers that study how the vega of a manager's portfolio must be addressed to achieve an ideal incentive package (Low, 2009).

Other studies concerning the relationship between insider trading laws and executive compensation focus on the possibility of extending the reach of insider trading laws so that they are better able to address such compensation components as executive stock option grants, which can encourage opportunistic behavior on the part of managers (Lie, 2005). Anabtawi (2003) identified evidence that highlighted how—since the prices of executive stock options are typically established as the company's stock price on the date the options are granted—managers are able to enhance the value of their option awards by timing grant dates to precede the release of favorable corporate news. She then noted that while such behavior might arguably constitute insider trading, the issue was open to debate because of gaps in current insider trading laws. More specifically, she posited that there were open questions in such cases, including whether the corporation or its shareholders have been deceived. Anabtawi proceeded to argue that both executives and boards of directors had at least some disclosure obligations to shareholders regarding the compensatory element of favorably timed grants. This led her to conclude that one could reasonably argue that such grants are subject to the same "disclose or abstain" rule that applies in traditional insider trading contexts.

Pro-regulation scholars have sought to trivialize this particular argument for deregulating insider trading (Prentice & Donelson, 2010), and Manne (2005) himself seemingly conceded defeat on this issue. However, I contend that this concession was premature, as a strong case can still be made that "insider trading-based compensation" would better align the incentives of management ("insiders") with those of shareholders ("outsiders") (Dye, R.A., 1984). The current approach of using options as an incentivizing device to get managers to pursue the interests of shareholders is flawed for reasons beyond those exposed by Lie in 2005. Options have expiration dates. As such, they inherently distill in managers a perverse incentive to decrease the firm's stock price at the time of the option grant and to take actions that will maximize the stock price at the option's expiration, even if doing so is not in the long-term interest of the firm (Goodman & Slezak, 2006).

Conversely, if managers are able to use their private information to obtain such "incentivizing" compensation, then they will not have such perverse incentives. Stocks are perpetual, so there is no benefit to executives to "game" the value of the stock price at any pre-specified point in time. Instead, managers would be best served by pursuing strategies that would optimize the long-term value of the firm, thereby maximizing the value of their equity holdings (Hu & Noe, 1997).

In pursuing such a course of action, both managers and shareholders would be following the edicts of modern portfolio theory. At the portfolio-level, all investors (insiders and outsiders) would benefit by focusing on the long-term returns to a properly diversified portfolio through the adoption of a "buy and hold" passive strategy. At the firm-level, the managers of each individual firm within the portfolio would be incentivized to maximize long-term shareholder value. By linearity of expected returns, this would ensure that the value of the portfolio would also be optimized over that same horizon. Moreover, the variance of the portfolio would be decreased because managers would no longer be "gaming" their actions to manipulate stock prices at specific points in time (Admati, Pfleiderer, & Zechner, 1994).

The promise of insider trading as a form of incentivizing executive compensation is highlighted by the failure of the current policy of awarding stock options to achieve desired results. Meulbroek (2001) noted that while option-based compensation was designed to effectively align managers' and shareholders' incentives, these incentives will not be aligned unless the firm's managers are exposed to firm-specific risk. She then explained how this prevents managers from optimally diversifying their portfolios, leaving them exposed to the firm's total risk. Nonetheless, the managers are rewarded—via expected returns—only for the systematic portion of the risk that they assume, so they value option-based compensation at less than its actual market value. Meulbroek labeled this difference between the market value of the options and the manager's perceived value of the options as "the deadweight cost" of such contracts. She empirically verified that this deadweight cost can be very large. As such, she concluded that option-based compensation is not cost effective. It seems unlikely that such deadweight loss would be a problem for insider trading-related compensation, because managers would be incentivized without forfeiting control over the degree of their portfolio diversification.

Several other recent studies also raise doubts about the efficiency of option-based compensation as an incentivizing mechanism. For instance, Dittmann and Maug (2007) found evidence that casts doubt on the role of option-based incentives as a proper form of executive compensation. More specifically, they established that, in the standard principal-agent model with constant relative risk aversion and lognormal stock prices, most CEOs should not hold any stock options. The authors argued that, instead, CEOs should receive lower base salaries, along with additional shares in their companies. Furthermore, in many cases, the CEOs would even be required to purchase additional stock in their companies. Dittmann and Maug (2007) found that existing compensation schemes are inefficient because this alternative arrangement would decrease average compensation costs by 20% without reducing the utility to CEOs. Clearly, these results differ substantially from the compensation schemes observed in practice. Therefore, the authors conclude that neither the conventional model nor any of its typical modifications can explain the pervasive practice of awarding stock options to CEOs.

Another advantage of replacing option-based incentives with insider trading-based incentives is that such a policy would make executive compensation more transparent to investors. Ordinary investors are baffled by the option-based incentives that currently comprise a large portion of managers' total compensation packages (Axelson & Baliga, 2009). These investors are often outraged when managers "cash in" the option components of their packages. If, instead, executives were incentivized with the ability to legally trade on their inside information, rather than with option-based packages, then existing investors would not have reason to complain, as they too would benefit from increases in the firm's stock price.

Clearly, no consensus has been reached about whether social welfare would be improved—via reduced executive compensation—if insider trading was deregulated. Thus, the topic discussed in this section is fertile for further research. A particularly interesting issue concerns the optimal trade-off between option-based incentives and insider trading-based incentives. One could construct a theoretical model to examine this issue, but would need to account for the other costs and benefits associated with the deregulation of insider trading. A game theoretic analysis could also shed some light on the issue. Such a study would be of interest to both researchers in this particular area, as well as those in the law and finance and corporate governance areas.

Issue 6: Chinese Walls

Multi-function securities firms—financial institutions with both investment banking and research analysis functions—establish Chinese Walls around equity research departments to prevent the spillover of information (Seyhun, 2008) and to avoid possible conflicts of interest influencing analysts' forecasts (McVea, 1993). "Chinese Wall" is a metaphorical designation used to describe the policies and procedures implemented by multifunction securities to stop the passage of price-sensitive information across the two firm divisions (Poser, 1997). The metaphor derives from the fact that Chinese Walls are adopted as a means to "wall in" information obtained from one department so that it cannot be leaked and then disseminated throughout the firm (Practicing Law Institute, 1989).

A better understanding of Chinese Walls can be obtained from a brief consideration of their historical development (Thomas & Nagy, 1995). Chinese Walls were first developed in a settlement between the SEC and Merrill Lynch. Many other multi-function securities firms voluntarily adopted Chinese Walls after the *Merrill Lynch* settlement, in an attempt to deter the SEC from targeting them in an investigation for insider trading (Poser, 1997). At the behest of the SEC, with respect to its efforts to help reduce analysts' conflicts of interests, Congress ultimately made Chinese Walls a statutory requirement under Section 15(f) of the Exchange Act, as part of its adoption of the ITSFEA (SEC, 2003). In light of the financial scandals of 2000-02, Congress and the SEC have more forcefully advocated the use of Chinese Walls as barriers for reducing analysts' conflicts of interest (SEC, 2002). It is worth noting that Chinese Walls have also been adopted in many developed markets outside of the U.S (Berg, 1991).

To summarize, Chinese Walls were created with the purpose of maintaining analysts' independence. They separate research and investment banking units, so that analysts are not tempted to provide biased research reports in response to pressure from the investment bankers (See also Dolgopolov, 2008). If Chinese Walls are effective, then they will eliminate, or at least reduce, the conflict between the interests of the investment banking division and the investors who rely on analysts' recommendations (Steinberg & Fletcher, 1994). Therefore, I will now consider whether Chinese Walls are actually effective.

Gorman (2004) outlined the theoretical advantages and disadvantages of Chinese Walls in the general setting, and Sullivan extended these results to the bankruptcy context (Sullivan, 2008). Regardless of the appeal of Chinese Walls "on paper," the evidence overwhelmingly indicates that they are not effective in practice. In other words, Chinese Walls are "porous" (Bodnaruk, Massa, & Simonov, 2009; Gorman, 2004; Lehar & Randl, 2006; Seyhun, 2008).

Thus, the literature on Chinese Walls is not favorable, as the policies do not seem to achieve their intended objective. Moreover, there is at least some doubt about who the policies are intended to benefit. This evidence confirms the general lack of effectiveness found for rules and regulations designed to deter insider trading. Consequently, there will most likely be an increased level of research into this controversial area in the near future.

Issue 7: Liquidity and the Cost of Capital

The relationship between a firm's cost of equity and the liquidity of its equity shares has been well documented. In the process, researchers have deconstructed the components of a firm's cost of equity in an attempt to isolate that portion of the cost that is attributable to liquidity risk (Diamond & Verrecchia, 1991). In most of these studies, the spread is used as a proxy for liquidity costs, where the spread is decreasing in liquidity. For instance, Amihud and Mendelson (1986) used the spread to establish that market-observed expected return is an increasing and concave function of illiquidity (See also Datar, Naik, & Radcliffe, 1998).

The question raised by these results is what the source of the liquidity cost is; or, equivalently, what drives investors to demand compensation for liquidity risk? Furthermore, even if one has an answer to this question, one might still wonder why the issue is relevant for a discussion of insider trading. The answers to these two questions are intimately related, as they both concern the adverse selection problem that arises out of the relationship between information quality and value uncertainty in a market with asymmetric information (Prentice & Donelson, 2010).

Akerlof won a Nobel Prize for his pioneering work in this area in which he theoretically linked information asymmetry and market value (Akerlof, 1970). While Akerlof focused his discussion on used cars, the principles derived in his paper generalize to any market setting that is characterized by asymmetric information. When assessing the value of a firm (in the form of a share of stock in the firm), if there is asymmetric information present (for instance, if the managers or insiders know something that investors do not), then the market value of the share may not reflect the intrinsic value of the share. More specifically, if investors are not able to distinguish between high quality firms and low quality firms ("lemons"), then they will only be willing to pay an average of the share prices for the two types of firms. As such, the average price will "undervalue" the high quality firms and "overvalue" the low quality firms. This will lead to an inefficient allocation of capital because high quality firms will not want to issue any equity, while low quality firms will want to issue too much equity (Fox, 2009). In other words, only lemons will be sold, so that no capital will be allocated to high quality firms, and social welfare will suffer as a result.

Thus, it is not surprising that pro-regulation scholars have long cited Akerlof's insights as a justification for insider trading regulations. Their argument is that regulating insider trading can limit the amount of information asymmetry in the market and, in the process, mitigate the effects of the lemons problem. In particular, just one year after the publication of Akerlof's seminal paper, Bagehot (1971) found that a primary cause of illiquidity in financial markets is the adverse selection which arises from the presence of privately informed traders. However, these arguments were more theoretical than practical.

Consequently, the next set of results in this stream of the literature focused on explaining how the lemons problem actually manifested itself at the market microstructure level. This required researchers to construct asymmetric information models of the trading process, and use them to illustrate that insider trading creates a lemons problem by impairing market liquidity. I will focus on a very stylized version of the most influential model in this area—the Kyle model (Kyle, 1985)—to illustrate how insider trading increases a firm's cost of equity by impairing the liquidity of that firm's securities.

In the Kyle model, a dealer serves as an intermediary between buyers and sellers. The dealer secures revenue by incorporating a spread into quoted prices (Kyle, 1985). Potential buyers and sellers consist of liquidity traders ("outsiders") and insiders. However, the market is anonymous, so the dealer is not able to discern whether he or she is dealing with an insider at any particular point in time. The asymmetric levels of information create an adverse selection problem in the market. The key portion of the dealer's costs—information trading costs—reflects this problem, because to avoid being a net loser in the market, the dealer must account for expected losses due to transactions with informed traders. Hence, the dealer sets the spread so as to account for these potential information trading costs. In particular, the assessed spread is increasing in the information trading cost. Recall that researchers use the spread as a proxy for liquidity. Therefore, liquidity is decreasing in the degree of information asymmetry. The implication is that a higher degree of information asymmetry leads to a larger spread. This is bad for liquidity traders, because they not only lose on average to insiders, but they also are charged a higher spread for each trade that they make, even though insiders are the actual source of the cost.

Demsetz (1986) built upon Kyle's model to show that, in the absence of regulations on insider trading, outsiders will effectively erect a natural defense mechanism against harmful insider trading by demanding higher expected returns on securities which have the highest potential for such activity. Key developments followed soon thereafter by, among others, Glosten (1989) and Bhattacharya and Spiegel (1991). The next series of papers in this area tested these theoretical propositions empirically. The initial results which focused on the U.S. markets were largely confirmatory (Brennan & Subrahmanyam, 1996; Chiang & Venkatesh, 1988; Chung & Charoenwong, 1998; DeMarzo, Fishman, & Hagerty, 1998; Fishe & Robe, 2004; Georgakopoulos, 1993). Subsequent research extended the analysis to international markets with equally supportive results at both the cross-country (Beny, 2007; Bhattarcharya & Daouk, 2009; Fernandes & Ferreira, 2009; Jain, 2006) and market-level (Brockman & Chung, 2003; Cheng, Firth, Leung, & Rui, 2006; Eleswarapu & Krishnamurti, 1995; Grammig, Schiereck, & Theissen, 2001).

To recap, the market microstructure models used Akerlof's insights to illustrate why dealers increase spreads in response to insider trading, and how this effectively decreases liquidity. These results on asymmetric information from the market microstructure literature are encouraging for pro-regulation scholars. They confirm that regulations are required to reduce the costs imposed on markets by the decreasing liquidity and increasing cost of equity associated with insider trading. However, market microstructure theorists recognize that some asymmetric information is actually a prerequisite for markets to function (Biais & Hillion, 1994; Milgrom & Stokey, 1982). Furthermore, the direction of causality has not yet been established. Moreover, recent studies challenge whether liquidity actually does improve market efficiency and whether insider trading actually does hurt market efficiency (Manne, 2005). In light of these recent developments, one can no longer state with certainty that, all else being equal, increases in liquidity lead to more efficient securities markets or that increases in insider trading lead to less efficient markets.

While some doubt has been cast on the asymmetric information school of thought within the insider trading literature, the bulk of the evidence still tends to support this view. This is to be expected, given the influential status of the market microstructure models in financial economics. Therefore, I expect that pro-regulation scholars will continue to appeal to the lemons problem in support of regulations that might decrease the level of information asymmetry in securities markets.

Issue 8: Prediction Markets

Prediction (or information) markets have been the subject of increasing attention across a variety of disciplines. Within financial economics, early studies focused on the microstructure and asset pricing implications of these markets. These aspects of prediction markets are interesting because the markets allow researchers to conduct controlled laboratory experiments to test a variety of hypotheses (e.g., risk aversion levels, behavioral biases) from law and financial economics. The first and most famous academic-related prediction market is the Iowa Electronic Market (IEM).

The accuracy and informational efficiency of these markets has been well-documented. Sunstein (2006) stated,

> prediction markets often produce extremely good answers. Such markets tend to correct rather than to amplify individual errors, above all because they allow shrewd investors to take advantage of the mistakes made by others. Because information markets provide economic rewards for correct individual answers, they realign incentives in a way that promotes disclosure. As a result, they are often more accurate than the judgments of deliberating groups. Highly successful companies, including Google and Microsoft, are using them. They should be, and will be, exploited for more often by the private and public sectors. (pp. 221-222)

In particular, prediction markets have proven to yield accurate (*ex post*), in absolute terms and relative to natural alternative prediction methods, forecasts at both short- and longhorizons (Chen, Mullen, & Chu, 2006; Ledyard, 2006; Wolfers & Zitzewitz, 2004). Furthermore, some of the concerns expressed by prediction market detractors have been allayed (Hansen & Oprea, 2009; Servan-Schreiber, Wolfers, Pennock, & Galebach, 2004). Consequently, the use of prediction markets is expanding both within asset pricing and across other disciplines.

A lot of attention is being devoted to the potential uses of prediction markets within corporations (Schreiber, 2004). These firm-level prediction markets are referred to as "internal" prediction markets, as opposed to the more familiar "external" prediction markets, which are open to the public. For instance, a plethora of books has been published in the last few years that are entirely devoted to how recent technology changes, when combined with the promise of internal prediction markets, may increase efficiency by changing the ways that companies operate (Kambil & Heck, 2008).

These issues have not escaped the attention of researchers (Richie, 2005). Myriad studies document that prediction markets can benefit corporations by allowing them to more efficiently aggregate information, better manage risks, improve decision making, and generate more accurate forecasts of new products (Gruca, Berg, & Cipriano, 2003; Hahn & Tetlock, 2006; Mainelli & Dibb, 2004; Malone, 2004; Spann & Skiera, 2003; Tziralis & Tatsiopoulos, 2007). Researchers have also confirmed the utility of prediction markets within specific markets, including those at Hewlett-Packard (HP) (Hogg & Huberman, 2002; Plott & Chen, 2002; Yang, 2005), Best Buy (Dye, R., 2008), and Google (Cowgill, Wolfers, & Zitzewitz, 2009).

Manne (2005) recognized that, given their demonstrated success at efficiently aggregating information, prediction markets are a source of potential interest to insider trading scholars. This insight led him to introduce a corporate governance dimension into the insider trading debate. The intuition is that insider trading regulations prevent relevant information from being quickly incorporated into market prices. As such, managers do not receive fully accurate "signals" from market prices. Manne suggested that prediction markets could serve as a useful "substitute" for this corporate governance mechanism when insider trading is prohibited. In light of the earlier discussions of the relative value of trades based on price-decreasing ("whistleblowing") information and the enormous costs associated with managerial gaming and inefficient option-based compensation, the potential importance of this argument is obvious.

Abramowicz and Henderson (2007) explored the implications of internal prediction markets for corporate governance in more detail. They contended that, by adopting prediction markets for corporate governance purposes, insiders would gain access to useful information and have the opportunity to anonymously profit from sharing this information with the rest of the firm. The implication is that firm insiders could channel their desire to use their material non-public information as a source of profit through internal prediction markets, without running afoul of public securities markets regulations (Abramowicz, 2004). Abramowicz & Henderson noted that the firm itself would actually benefit from this trading, because its managers would be able to access the inside information needed to most efficiently manage the firm. Consequently, they concluded that internal prediction markets could harmlessly circumvent existing insider trading laws.

I would like to see this evidence on the promise of prediction markets stimulate anti-regulation scholars to focus less on repealing insider trading regulations—and the debate in general—and more on the use of internal prediction markets as an avenue available for insiders to usefully profit from their information. By adopting internal prediction markets, firms could better align shareholder and managerial interest without violating the stated purpose of existing securities laws or other proposed reforms (Hanson, 2008). Therefore, at least at the firm-level, shareholders should encourage the adoption of corporate prediction markets because these markets could generate most of the benefits of allowing insider trading without the associated costs.

So why have no such shareholder initiatives followed in the wake of Manne's analysis? The problem is that the opaque regulatory status of prediction markets in the U.S. has had a chilling effect on the spread of these markets. Surprisingly, there are significant regulatory barriers to establishing prediction markets in the U.S., largely because these markets are potentially subject to gambling laws (Bell, 2009). In an encouraging development, a group of respected scholars submitted a statement to U.S. regulators appealing to them to lower barriers to the creation and design of prediction markets by creating a safe harbor for certain types of small stakes markets (Arrow, et al., 2007).

Cherry and Rogers (2008) extended the work in this area by identifying the expressive elements inherent in prediction markets and exploring how existing regulations harm such predictive speech. They also distinguished prediction markets from the other areas that are subject to the restrictive gambling laws, and argued that there is an expressive element to these trades in that each person who participates in an information market is, in essence, offering his or her opinion on the outcome of an uncertain future event. The implication is that, due to Constitutional protections, any existing regulations in these areas should not be applied to prediction markets.

In spite of the lack of clarity with respect to the legal status of internal prediction markets, the reviewed studies suggest that corporations would not be violating any existing U.S. regulations by adopting such markets. As such, I expect to see the use of these markets spread in the near future. Nonetheless, I hope that legislators will soon recognize the promise of prediction markets and publicly announce a position that encourages their widespread use.

Issue 9: The Trade-off (Liquidity versus Governance)

I saved the discussion of the liquidity-governance trade-off until last because it arises at the intersection of all of the previously discussed issues. The trade-off concerns the relationship between the liquidity of a firm's shares and the manager-shareholder contracting within that firm. The importance of this issue has been recognized by both legal and financial scholars (Becht, 1999; Eleswarapu & Krishnamurti, 1995; Kothare, 1997; Lerner & Schoar, 2004).

Large, active stockholders can reduce agency costs by internally monitoring management, but the downside is that dispersed ownership is associated with increased liquidity levels. Symmetrically, the decreased liquidity associated with highly concentrated ownership can exacerbate information asymmetries, while increased liquidity can make it less costly for the large shareholders who are most effective at monitoring the firm to "exit" by selling their shares. However, my analysis to this point has been incomplete because I have treated the individual issues in isolation, while they are not, in reality, independent. Thus, I must now extend my analysis to account for possible problems with endogeneity and simultaneous causality.

In a seminal analysis, Demsetz (1986) examined the role played by insider trading in the inverse relationship between concentrated ownership and liquidity. He noted that investors who chose to take a large stake in the ownership of a particular firm burdened themselves with firm-specific risk, a cost not borne by minority shareholders. This prompted him to analyze why large shareholders voluntarily chose to assume firm-specific risk. Demsetz hypothesized that large shareholders voluntarily chose to assume firm-specific risk because insider trading affords them supplemental compensation that offsets the costs of assuming such risk. Moreover, he did not think that this use of insider trading was a bad thing for the other shareholders in the firm, as large shareholders, who are better able to monitor the firm, are more incentivized to do so. In other words, the cost of insider trading is a welfare transfer borne by minority shareholders in exchange for more effective governance. This led Demsetz to conclude that policies designed to reduce insider trading profits are likely harmful because they make it more difficult to maintain the controlling ownership interests needed for effective firm monitoring.

Coffee (1991) provided a legal analysis of the trade-off between the liquidity associated with dispersed ownership and the corporate monitoring associated with concentrated ownership, and surmised that political considerations are the fundamental reason that U.S. capital markets have developed to prioritize liquidity over control. Underpinning Coffee's analysis is a shared belief with Demsetz that existing regulations effectively deter institutions from actively monitoring firms. In a complementary study, Bhide (1993) confirmed that political considerations have helped shape the U.S. markets toward higher liquidity and lower investor activism. The implication is that public choice theory should inform any serious analysis of the trade-off.

Recent advances in the market microstructure literature have allowed scholars to conduct more powerful tests of the trade-off. Most of these studies reached the same conclusion as did Demsetz—at the optimum, firms trade-off the benefits of increased managerial effort against the lower price they get for their shares when they are issued in the capital market (Bolton & Von Thadden, 1997; Heflin & Shaw, 2000; Holmström & Tirole, 1993; Rubin, 2007; Sarin, Shastri, & Shastri, 2000). However, while the results in this section seem to provide strong evidence in support of the view that liquidity and ownership concentration are inversely related, the issue is not without controversy. For instance, Kini and Mian (1995) contradicted this view in their empirical analysis of the predictions of asymmetric information models about the spread, as they documented a significantly positive relationship between blockholdings and the spread. In an even more influential analysis, Maug (1998) disputed the claim that liquid stock markets prevent effective corporate governance. He constructed a theoretical model and used it to show that large shareholders have an incentive to monitor firms and that the impact of liquidity on corporate control is unambiguously positive. As such, Maug concurred with

Kini and Mian that the alleged trade-off between liquidity and control does not actually exist.

Regardless of the true nature of the trade-off between concentrated ownership and liquidity, there is an even more fundamental debate in this area. In particular, the trade-off issue relates the costs of the decreased liquidity to the benefits of improved governance. However, it is not clear that concentrated ownership by large shareholders actually improves corporate governance. On the one hand, numerous scholars have found that concentrated ownership is valuable because it helps to solve the asymmetric information problem through more intense monitoring of corporate management (Almazan, Hartzell, & Starks, 2005; Faure-Grimaud & Gromb, 2004; Huddart, 1993; Zeckhauser & Pound, 1990). On the other hand, a few researchers have questioned the desirability of having large outside shareholders, as concentrated ownership has possible disincentives for managerial performance (Burkart, Gromb, & Panunzi, 1997).

An additional factor complicating the trade-off is the fact that large shareholders have a simultaneous interest in speculating on a firm's shares. Kahn and Winton (1998) were the first to explore the possibility that market liquidity could undermine effective control by giving large shareholders excessive incentives to speculate rather than to monitor. Aghion, Bolton, and Tirole (2004) extended this analysis in the first ever study of the optimal design of active monitors' exit options in a problem involving a demand for liquidity and costly monitoring of the issuer. They concluded that there is a fundamental complementarity between information-increasing speculative monitoring in financial markets and agency-decreasing active monitoring inside the firm (Aghion, Bolton, & Tirole, 2004). These two papers highlight the fact that the liquidity-monitoring trade-off is more complex than originally thought. The decision facing large institutional shareholders is not merely whether to monitor—it is whether to monitor or to speculate. Hence, the trade-off can be more accurately described as one between the conflicting incentives of large shareholders (speculation versus monitoring) and liquidity.

Underlying my discussion of the trade-off is the fundamental goal of reducing the lemons problem that arises out of asymmetric information between insiders and outsiders. In fact, insider trading regulations (market-level) and external monitoring by shareholders (firm-level) is justified in large part by the need to ameliorate the problems associated with asymmetric information. While some of these insider trading regulations are specifically designed to help facilitate external monitoring, researchers disagree about their social utility (compare with Li, Moshirian, Pham, & Zein, 2006 with Becht, 2003, and Padilla, 2005), even though domestic and international evidence supports the hypothesis that concentrating ownership and liquidity are inversely related (Cueto, 2009: Earle, Kucsera, & Telegdy, 2005; Ginglinger & Hamon, 2007; Naes, 2004).

On net, the existing evidence suggests that firms with large shareholders have better governance and less liquid shares than do those with more dispersed ownership. However, there is little support for the pro-regulation position that regulations can elicit decreases in information asymmetries through the facilitation of external monitoring. Therefore, regulators should probably not interfere with the firm-level trade-offs achieved via market exchange.

For my purposes, I am particularly interested in the trade-off's implications for insider trading. I have established that increased liquidity is valuable because it helps to ameliorate the lemons problems that arise in markets where insiders trade on asymmetric information. I have also documented that effective corporate governance—in the form of insider monitoring—decreases the likelihood that insiders can trade on their inside information. Hence, by increasing transparency, both liquidity and corporate governance help to alleviate agency problems. The problem is that each of these factors also has a cost that must be accounted for when considering the optimal trade-off for a particular firm. That being said, in practice, the complex nature of the relationship between liquidity and monitoring discussed in this paper makes an assessment of the optimal trade-off difficult.

One of the very few conclusions that can be drawn from the existing work in this area is that there is a trade-off between liquidity and governance, and this trade-off has important implications, both for firm efficiency and for the prevalence of insider trading. Recall that even this conclusion has been disputed (Maug, 2002). The research in this area is unsettled, so I expect the trade-off to remain an important topic for future work in the insider trading literature. In particular, no study has provided any guidance on how each firm should weigh the costs and benefits in choosing its own optimal level of the trade-off. Consequently, there is a need for research that sheds light on the characteristics of such an optimal trade-off.

An intriguing possibility in this area would involve merging the trade-off with yet another one of my previous issues—prediction markets. A prediction market study would afford a researcher the opportunity to conduct actual experiments to assess the optimal trade-off between liquidity and governance in a laboratory setting. The researcher could readily vary all relevant parameters, including a firm's cost of capital, the level of information asymmetry in the market, insiders' propensity to trade on inside information, and the insider trading laws regulating the market. This research design reveals one of the benefits of prediction market studies—they allow scholars to isolate the problem of particular interest to them. Relevant theory would guide the researcher in constructing a model for determining the utility that would be generated by the introduction of a prediction market in which a firm's level of liquidity is traded-off against the associated level of monitoring.

Grossman's seminal analysis of the introduction of futures markets as informational devices could be extended analogously to the case of prediction markets. In particular, one could construct a baseline measure of the level of information (utility) in the existing system without a predictions market. The researcher could then assert the informational role for the prediction market with respect to the trade-off between monitoring and liquidity. Finally, he or she could use the model to examine the effects on the information (utility) level in the market after the introduction of the prediction market. This would allow the researcher to isolate the actual value, if any, added to the market as a result of introducing a prediction market. After obtaining results from a variety of scenarios (parameter values), the researcher could assess the relative contributions of liquidity and governance to the increase in total utility.

Concluding Remarks

In this chapter, I have gathered in one place the major results from the existing body of insider trading research. My analysis of these results has been through the lens of financial economics, but I have sought to, wherever possible, highlight potential topics for future research which are also of interest to legal scholars. The insider trading debate is no doubt compelling. However, scholars must face the reality that the massive amount of ink that has been spilled in analyzing this issue has not brought them any closer to resolving the issue than they were when Manne introduced it almost fifty years ago. Furthermore, in practice, whether they enforce them or not, most securities markets have adopted insider trading regulations. The upside is that, as noted in this paper, there are a number of significant issues that are worthy of being analyzed by the brightest scholars in this area. Therefore, it is my hope that this chapter sparks a new debate—one about the future direction of insider trading research.

CHAPTER 2
DIVERGENCE OF OPINION AND CONVERGENCE OF PRICES IN PREDICTION MARKETS

Introduction

The *rational expectations* ("RE") assumption underlies much of empirical research in financial economics across a range of topics including tests of asset pricing models. While not required by the standard models in finance, the assumption is particularly convenient from the standpoint of empirical research design. It greatly simplifies the task of estimating and testing asset pricing models by allowing the researcher to use the empirical distribution of returns as a proxy for the *ex-ante* (unobserved) beliefs of agents. Of course, this also creates the classic joint hypothesis problem. The typical test represents a joint test of the model and the underlying assumption leaving it unclear whether a rejection implies a failure of the model, or simply a violation of the rational RE assumption due to the biased prior beliefs of agents.

Bossaerts (2004) proposes an alternative framework for testing the rationality of asset prices without imposing the restrictive RE assumption. An appealing feature of the framework is that it allows the researcher to test whether agents' beliefs update in a rational (Bayesian) fashion, without having to explicitly specify agents' priors. Essentially, the framework implies a set of prior–invariant martingale restrictions on asset prices. In this study, we test Bossaerts' Efficient Learning Hypothesis ("ELM") using a unique dataset from the Iowa Electronic Markets ("IEM") that allows us to observe agents' prior beliefs. As we discuss below, the latter feature allows us to provide novel evidence on the question of how errors in prior beliefs may impact the evolution of prices in asset markets.

Before we discuss our data set, we summarize our results. Contrary to the RE hypothesis, traders in our markets start with erred (and heterogeneous) beliefs. However, consistent with the ELM, traders update their beliefs in accordance with the rules of conditional probability. Hence, under the standard RE-based methodology, the investors would be deemed irrational and the market concluded inefficient, whereas they are found to be, respectively, rational and efficient, under the ELM methodology. Furthermore, price convergence is statistically independent from the magnitude of traders' errors and the dispersion in their beliefs.

The remainder of the chapter is organized as follows. The next section describes the unique data set that is the focus of our study. The third section reviews RE and the ELM alternative. The fourth section explains our methodological approach. The fifth section discusses the results of our tests. The sixth section concludes the chapter.

Data

Prediction Markets and the IEM

Lab experiments and their prediction market extensions provide direct tests of how well markets process information (Forsythe et al., 1992). Information processed is not under the control of the experimenter. Traders rely on some combination of public information (e.g., political polls) and private information for their trading.

We use data from the best-known prediction market, the IEM, to build on these existing studies. The IEM's fame stems from its consistently accurate political market predictions, but it also hosts markets to forecast stock price levels, corporate earnings, stock returns and changes in Federal Reserve policy, among others (Berg et al., 2003, 2007) and (Pennock et al., 2000). The IEM is described in detail at its website (www.tippie.uiowa.edu/iem/) and in the extant literature. Its success in forecasting election outcomes, among others, are well documented.

Prediction markets have been shown to accurately aggregate consensus forecasts as well as the entire distribution of traders' private information (Gruca et al., 2005). They also efficiently summarize the information contained in survey forecasts, while reducing their variability (Gruca et al., 2003). Prediction market efficiency obtains even when traders are a non-representative, consistently mistake-prone and biased individual traders, so long as the market's structure encourages rational (marginal) traders to drive prices (Forsythe et al., 1999; Oliven & Rietz, 2004). These results provide strong support for the ability of markets to distill and incorporate all payoff-relevant information, in accordance with RE.

Prediction markets have other unique features that make them particularly amenable to empirical study. First, the markets are structured so that their prices can be interpreted as probabilities of the underlying events of interest. The overwhelming majority of studies on prediction markets, including Bondarenko and Bossaerts (2000), support this assertion. Second, the relatively simple trading environments minimize the otherwise challenging demands placed upon them by asset pricing theory. Third, the markets are relatively close approximations to the idealized ones assumed in asset pricing theory: they are complete, free of transaction costs, operated continuously, endowed with essentially divisible assets and a common interest rate, etc. Fourth, prediction markets provide readily available information on outcome realizations that are reasonably exogenous.

These myriad unique benefits make prediction markets the ideal setting in which to investigate how asset prices relate to the posterior beliefs of traders. In supporting this position, Ottaviani and Sorenson (2011) assert that "[g]iven the simplicity of the trading environment and the availability of data on reasonably exogenous outcome realizations, *prediction markets are ideal laboratories to test theories of market efficiency. Indeed, the Iowa Electronic Markets were initially developed for educational purposes*" (p. 2, emphasis added). Our novel data set allows us to examine dynamic price reaction to information in the presence of heterogeneous priors and wealth effects.

IEM Movie Markets

The IEM occasionally runs markets in winner-take-all ("WTA") contracts for which the contracts being traded are linked to the domestic box office performance of the movie specified in the market's prospectus. A sample prospectus is provided in

Appendix F. Our sample consists of the 21 markets held during the years between 1998 and 2008. We refer to this set of markets as “the IEM Movie Markets.” Four-to-six WTA contracts were traded in each of the markets (These are pre-split values. The post-split values are 4-8). See Table A1 for more details.

Contract liquidation values are determined by the cumulative U.S. box office receipts earned by the underlying movie during its first 4-weeks of release, as published in Variety’s Domestic Box Office Report. Thus, the underlying outcome is non-negative, continuous, wide-ranging, and at least theoretically, unbounded from above. Traders are confronted with the formidable task of forecasting this 4-week total for a particular movie. The IEM Movie Markets then aggregate the consensus forecast of this continuous underlying outcome.

We convert the continuous underlying outcome space into a discrete outcome space. We do this by segmenting the space into a small number of mutually exclusive and collectively exhaustive ranges, with each range being associated with a contract. As none of the contracts overlap and the entire theoretical range of box office receipts is fully spanned by the union (“portfolio”) of contracts, each set of contracts constitutes a bundle of outcome-spanning Arrow-Debreu (“A-D”) securities for a particular movie.

At the end of the market, the realized cumulative box office total will obviously fall somewhere within that movie’s theoretical range of values. By extension, this realized value will fall within one and only one of the ranges which define the contracts for that market. The unique contract identified with this range is deemed the “winner.” It liquidates for $1. Analogously, the remaining contracts are deemed “losers.” They liquidate for $0. This ensures that exactly one of the contracts will expire in the money.

The binary data structure obtained from our partitioning of the outcome space allows us to apply digital option pricing results to the contracts, and to interpret prices of individual contracts as the probability that the partition of the outcome space associated with that contract will include the final outcome. Consequently, we can determine how efficiently the market aggregates the distribution of traders' private information, while capturing the two crucial aspects of the traders' private information: the consensus forecast and the dispersion of forecasts around this overall consensus (Gruca et al., 2005).

The trading mechanism of the IEM is a computerized double auction ("CDA"), the same system employed by NASDAQ. CDA markets are assured of not losing money, as they are zero-sum markets, by design. Traders can access the markets 24-hours a day, 7-days a week via the Internet, extending access beyond the University of Iowa to would-be participants with an academic affiliation. However, total investment by each trader is capped at $500. Decisions made by traders have immediate consequences. The total value of their investment is entirely dependent on their trading choices.

Through its website, the IEM makes the continually-updated best bid and ask, as well as the last trade price, freely available to traders. Traders can also access historical daily price information consisting of the quantity and dollar volume and the high, low, average and last trade prices. Traders do not know the quantity available at the best bid and ask. Nor do they know other entries in the bid and ask queues, except for their own bids and asks. While the IEM markets are continuous, price information is reported in 24-hour daily segments ("periods"). Closing prices are the last trade price before midnight each day. If no trade occurs in one 24-hour period, then the closing price from the immediately preceding 24-hour period is carried over. Prices in bid and ask queues are posted in increments of $0.001.

Traders can acquire contracts in one of three ways: market orders, limit orders, or bundle purchases. The ways to dispose of a contract follow analogously. Traders seeking to purchase a contract immediately must either submit a market order or purchase a bundle directly from the IEM system. When submitting a market order, the trader must agree to pay an amount equal to the lowest available ask from another trader in the market in exchange for the contract. This represents the best "posted" market price for that contract at that point in time. When purchasing a bundle, the trader must agree to pay $1 to the IEM system in exchange for one of each of the contracts available for sale in that particular market. The trader can still effectively acquire the single desired contract in this way, because he/she can immediately sell the other assets in the bundle in exchange for an amount equal to the sum of the best bids from other traders in the market for those "non-desired" contracts.

The third way to purchase a contract is only of interest to traders who are not necessarily seeking to immediately acquire the asset; for delayed possible execution, a trader can submit a limit order, which includes a bid higher than the existing maximum bid and a time limit on the offer or is below current best bid. These limit orders are queued by price and submission times. Infeasible orders (bids, asks, purchase orders and sell orders) may be submitted but can never result in trades.

The IEM system continually stands ready to purchase or sell a bundle of contracts for $1 (the guaranteed liquidation value of the bundle). This maximizes liquidity, and endows the market with a perfectly elastic level of supply and demand. The total number of contracts outstanding at any point in time is determined entirely by trader demand. The "aggregate endowment" in any particular market has a fixed structure, as there will always be an equal number of each contract in circulation at any time. This maintains the zero-sum market structure, in the process. This structure creates a risk-free portfolio which serves as a natural numéraire which, coupled with the fact that a method to "replicate" any asset is built-into the IEM, allows investors to engage in arbitrage pricing. Traders simply have to go long a bundle and short all but the asset that he/she seeks to replicate.

Traders in these markets included graduate business students as well as other participants with an academic affiliation (student, staff or faculty). More than half of the students we had demographic information on had two or more years of working experience before returning to school. The vast majority of students had completed or was enrolled in a course in Managerial Finance.

As part of a marketing course, students completed a class assignment that asked them to submit forecasts (a point estimate) of the movie's box office receipts in the first four weeks of release in theaters. A sample forecast survey is included in Appendix G. The students supplied detailed justifications (four to five pages) for their forecasts. Traders did not know the contract definitions until after they had submitted their forecasts. Student traders each received \$5 or \$10 trading accounts that they could redeem for cash after the market liquidated, provided they executed at least two trades. Students were free to add their own funds to their trading accounts. Student forecasts were submitted before the associated IEM Movie Market opened. This allows us to fairly assess how the market aggregates private, heterogeneous information dispersed at the individual level across traders. As such, traders were not able to condition on the information used by other investors, because no trading had yet taken place. Once the movie opened in theaters, trading continued for four weeks. Contracts liquidated shortly after the markets closed. Timeline for the IEM Movie Markets is provided in Figure B1.

The student forecasts in this study are distinctive and valuable data, as they reflect the *ex ante* private information held by traders in a real-money prediction market associated with a real-world event. Traders were entirely responsible for acquiring the information they used to prepare their forecasts and they were not restricted in any way. No payoff-relevant information was provided by an experimenter. These unique features of our data set are what allow us to provide a "clean" test of Bossaerts' ELM (2004). We have the entire distribution of trader forecasts, so we capture both the consensus forecast and the dispersion (degree of disagreement) in the forecasts. The importance of this aspect of financial data is widely acknowledged.

As documented by Gruca et al. (2008), the four week post-opening period in the IEM Movie Markets is almost identical to that of the web-based Hollywood Stock Exchange ("HSX"). Thus, once the movie has opened at the box office, traders can subsume HSX price data within their information sets, should they choose to do so, thereby updating their forecasts in light of information revealed by HSX traders. We take advantage of this feature in our study, by analogous to IEM political market analysts who benchmark the accuracy of those markets with pre-election polls, using HSX forecasts as the frame of reference for the IEM Movie Market. We do so without hesitation, as the IEM Movie Markets and HSX markets have statistically indistinguishable levels of accuracy and highly correlated percentage errors (Gruca et al., 2003, 2008). The correlation of the forecast percentage errors for the two markets is greater than 80% (Gruca et al., 2008).

HSX markets, first held in April 1996, have been in operation for almost as long as the IEM Movie Markets. HSX markets are prediction markets, but unlike the IEM, they do not use real money and the contracts are not Arrow-Debreu securities. As of 2008, there were more than 1.5 million registered participants in the HSX markets.

We use the formulas provided on the HSX website, www.hsx.com, (internal-multiplier based forecasts) to construct HSX forecasts. All but one of the 18 movies for which we have forecasts opened on a Friday. The forecasts for those movies are determined by multiplying the opening-weekend (Friday, Saturday, and Sunday) box office by the associated internal multiplier value of 2.7. The remaining movie, font, opened on a Wednesday (Thanksgiving holiday weekend). Its forecast is determined by multiplying the opening-weekend box office by the internal multiplier value of 2.0, where the opening weekend also includes box office revenue from Wednesday and Thursday.

Methodology

In empirical tests of asset pricing models, researchers inevitably assume that markets have equilibrated in such a way that the return distributions under study satisfy the well-known stochastic Euler equation, for all assets, *n*, and all time periods, *t*

$$1 = E_t^n \left[m_{t+1} R_{t+1}^n \right], \tag{2.1}$$

where R^n_{t+1} is the gross return earned on asset n over the period from time t to time $t + 1$

$$R^n_{t+1} = \frac{p^n_{t+1}}{p^n_t}, \tag{2.2}$$

and m_{t+1} is the stochastic discount factor ("SDF") of the model

$$m_{t+1} = \beta \frac{u'(c_{t+1})}{u'(c_t)}. \tag{2.3}$$

These empirical tests are complicated by two factors. First, we lack data on individual-level consumption. Second, we do not directly observe the individual-level *ex-ante* subjective probability assessments that investors use to calculate the expectations in (2.1). The latter issue is particularly thorny, because, while it is at least possible to gather individual-consumption data (or some proxy thereof), it is not possible to read minds. We will also see that an argument can be made for using aggregate-level consumption data in our empirical tests. Thus, at least for our purposes in the present paper, we suppose that we can obtain some reasonable "consumption measure," and focus on the second, more challenging, issue: unobservable expectations.

The vast majority of studies assume RE and efficient markets. In his 2000 paper with Oleg Bondarenko, Bossaerts refers to these collective assumptions as "RE." However, in his later works, he refers to them as "EMH" (Bossaerts, 2002, 2004). We will follow his original approach and refer to them collectively as "RE." RE allows researchers to avoid modeling the learning ("beliefs formation") process altogether. The general idea is that, at least for empirical purposes, we can infer the subjective expectations that investors held *ex ante* from the *ex post* prices that are observed in our sample. By implication, investors are required to have unbiased priors and to update these priors rationally in accordance with Bayes' law.

Based on his observations from laboratory experiments, Bossaerts objects to the sub-assumption that investors must have *ex ante* unbiased priors. He thus proposes an alternative to RE—the ELM—for which only the rational updating of priors is required (Bossaerts, 2004). The ELM requires that, given an arbitrary, unknown prior and a known, fully specified likelihood, investors update their beliefs rationally (Bossaerts, 2002).

Bossaerts argues that the ELM is a more tenable assumption than RE because rationality is a characteristic of *learning*, not of *ex ante beliefs*. Lewellen and Shanken (2002) have also argued in favor of this reconceptualization of rationality. The reasoning is that markets are incomplete information environments, so investors must learn about unknown, payoff-relevant parameters by updating arbitrarily-biased priors in light of all observed information. Markets evolve along with investor beliefs by impounding the information, on the basis of which investors are induced to trade, into current prices.

If investors are rational, they will employ all available payoff-relevant information in forming their forecasts. Bossaerts (2004) uses this reasoning to recover a martingale property (facilitate econometric testing of moment conditions) for his ELM methodology: average modified returns are zero, in expectation. As a result, changes in asset prices will be unpredictable, as they form a martingale difference sequence. In probabilistic terms, a market that uses Bayesian analysis to update its beliefs on the basis of the correct likelihood of information is a rational one, irrespective of any bias in its initial belief.

Bossaerts (2004) further develops novel empirical methods with which to test the ELM. These empirical methods center on a technique for "filtering" returns for any biases present in the sample under study. The methodology also requires researchers to classify securities into "winners" and "losers" categories, based on the *ex post* realized state (outcome), and then exclude the "losers" from the statistical tests (Bossaerts, 2004). Filtering returns turns out to be extremely simple. Researchers merely to multiply the traditional net return by the ratio of the *ex ante* price to the *ex post* price. The resulting modified return differs from the traditional return only in that it uses the future price, rather than the previous price, as basis

$$x_{t+1} = \frac{p_{t+1} - p_t}{p_{t+1}}. \quad (2.4)$$

As this modification of the denominator filters for arbitrary biases, left intentionally general here, in the market's prior, the ELM methodology is more robust than the RE methodology. Also, test statistics based on modified returns have been shown to have excellent statistical power properties (Bossaerts & Hillion, 2001).

Bondarenko and Bossaerts (2000) implement these tests to examine investor rationality and market efficiency in the IEM markets. Bossaerts and Hillion (2001) perform the same analysis for IPOs from financial markets. In both cases, the authors find anomalous evidence of predictability of returns. However, after filtering the returns for biases, they are able to conclude that the predictability is merely an *ex post* illusion.

The RE assumption is clearly fragile when it comes to biases. This is far from trivial, as it leads researchers to falsely infer the existence of anomalies. By conditioning on *ex post* knowledge of "survival status," researchers appealing to RE effectively impute a selection bias into the data that masks otherwise efficient learning by traders. The ELM renders existing assumptions harmless by suitably modifying our empirical methods in such a way that they are robust to the existence of any biases, including those resulting from *transient learning* that occurred during the period under study.

In this chapter, we examine whether traders who start with priors that are known to be biased, nonetheless, rationally learn from information revealed over time. We replicate the tests in Bondarenko and Bossaerts (2000) and confirm that ignoring the bias induced by implicitly conditioning on full sample survivorship status leads to the false inference that traders are irrational, while the ELM correctly recognizes the efficiency of trader updating.

Our intent is not to disparage prior studies that have relied on the RE assumption. As acknowledged in the preceding discussion, the stochastic Euler equation has no empirically-testable content in the absence of some additional "identifying" assumptions. Additionally, the advantages of the RE assumption are inarguable—it provides us with a way around the two problems noted above: (1) we can test our theories with aggregate measures of consumption, as individual-level consumption data is not required, and (2) we do not need to worry about modeling the expectations-formation (i.e., learning) process, because we have converted agents' beliefs from model inputs to model outputs (Hansen, 2007).

The replication component of our analysis is facilitated by the fact that we know the entire distribution of trader forecasts. The extension portion of our paper benefits from another important feature of our data set: our contracts are true A-D securities. Hence, we can appeal to binary option pricing methods even though there is no traded underlying security in our markets. Furthermore, a simple Black-Scholes valuation is neither feasible nor desirable for myriad reasons, including the well-known problem of skewed volatility. Binary options follow the discontinuous (at settlement), Heavyside function. As such, they are subject to significant convexities at extreme price and time to maturity levels. This volatility skew is documented for prediction market data by Majumder et al. (2009). Similarly, Bondarenko and Bossaerts (2000) find that volatility is higher at price levels near zero/one (esp. near zero) than for prices between these 2 extreme cases. They (partially) deal with this heteroskedasticity-type issue by scaling all values by lagged price. However, they are not able to go beyond this to examine the 2 possible sources of bias to assess their relative impacts, as they do not have the data required to reconstruct the forecasts distribution.

Another feature of our data set that is at odds with the Black-Scholes option pricing model is that contracts are characterized by a pricing discontinuity observed at maturity: an implicit "jump" is associated with each contract traded in a WTA market. The lone winning contract benefits from an upward jump that is equal in magnitude to the difference between its liquidation value of $1 and its last observed price prior to the payoff-determining event. Analogously, the remaining contracts, all of which are losing contracts, suffer from downward jumps equal in magnitude to the difference between their liquidation values of $0 and their respective last observed prices prior to the payoff-determining event.

We take advantage of the equivalence between the payoff structure of our contracts and that for binary options, by appealing to a recent breakthrough in the pricing of dynamic binary options made by Majumder et al. (2009). We refer to this model as the "jump model". The jump model captures the conditional diverging volatilities that characterize the binary options traded in WTA prediction markets. It incorporates conditional asymmetric upward and downward jumps with volatility that increases as one approaches the contractually-specified closing date. We employ the model to quantitatively decompose the relative contributions of the mean and standard deviation of forecast error present in prices observed *ex post* to determine the mechanism by which biased priors affect market prices

It is worth noting at this point that the conclusion reached by Bondarenko and Bossaerts based on "predictability tests," which are implementations of the RE methodology and, as such, are restricted to winning contracts, is tautological. Returns on "winning" contracts will have to be negatively related to lagged price levels. Bossaerts is aware of this himself, given his proof that returns on winning contracts will be significantly positive, on average (Bondarenko & Bossaerts, 2000). This is particularly obvious in the IEM context, where prices are bounded by 0 and 1. In contrast, the similar results observed by Keim and Stambaugh (1986) in stock and bond markets, which are referenced by Bondarenko and Bossaerts (2000), are not tautological, because they do not condition on final outcome status.

We now detail how we use the jump model on our daily data to estimate the speed of convergence parameter, γ, for each of the 18 markets for which we have forecast data. In our replication analyses, we indexed the individual movie markets by i, where $i = 1, 2, \ldots, N$, with $N = 21$. However, in this extension section, we are limited to a consideration of a subset (18) of our original 21 markets, as forecast data was not collected for 3 of the markets: mat, sun, and tti.

We index the 24-hour intervals in the *N* individual time series by τ^i, where $\tau^i = 0$ denotes the closing date for movie *i*, as specified in its IEM Movie Market prospectus, and τ^i refers to the τth-to-last day for movie *i*. We then set the origin of the time axis at the closing date for each of the *N* markets. To avoid issues that may arise as information comes in on the maturity date, we only analyze data up to midnight the day before the closing date. As such, we effectively choose the closing date as the common date with respect to which we align the markets in relative time, and the 1st-to-last day in each market as the common terminal 24-hour interval that we actually consider in our relative time analysis.

Analogously, $\tau^i = T^i$ denotes the opening date of the IEM market for movie *i*. While the markets share a common closing date in relative time, this is not the case for their opening dates, because the markets are not open for an identical number of days. In particular, T^i differs from movie-to-movie, with a minimum of 31 total days for isk and a maximum of 46 total days for font. Thus, without loss of generality, we can drop the superscript (*i*) in our references to the relative dates for all but the opening 24-hour interval, which we will continue to denote as T^i.

After discarding the losers and pooling the movie-day observations for the winners from the 18 markets for which we have available forecasts, we are left with 690 total data points. To maintain consistency and comparability with the replication analyses, we continue to consider only winners. Upon deleting the single observation for each market that came in on the maturity date, we are left with an aggregate sample of 672 24-hour intervals. We base our extension analyses on these 672 observations.

To elucidate our continued consideration of both the unnormalized price series and the normalized price series without allowing for undue proliferation of equations, we also add an index, *k*, with which to distinguish the 2 types of price series, where

$$k \in K \text{ and } K = \{Unnormalized\ Price\ Series,\ Normalized\ Price\ Series\}. \tag{2.5}$$

Under this indexing scheme, we denote the price series by

$$\mathcal{P}_k^i\left(\tau^i\right) \forall k \in K; i \in N. \tag{2.6}$$

Similarly, we denote the return series by

$$\mathcal{R}_k^i\left((t-i)^i\right) = \frac{\mathcal{P}_k^i\left((t-1)^i\right) - \mathcal{P}_k^i\left(\tau^i\right)}{\mathcal{P}_k^i\left((t-1)^i\right)} \forall k \in K; i \in N. \tag{2.7}$$

Per Majumder et al. (2009), we hypothesize that the current value of the winner (current value of the contract that "settles at" a value of \$1) for movie market *i* evolves according to the stochastic process specified by the jump model

$$\mathcal{P}_k^i\left(\tau^i\right) = \begin{cases} \mathcal{P}_k^i\left(\tau^i\right) + \dfrac{1-\mathcal{P}_k^i\left(\tau^i\right)}{\left(\tau^i\right)^{\gamma_k^i}}, \text{ with probability } \mathcal{P}_k^i\left(\tau^i\right) \\ \\ \mathcal{P}_k^i\left(\tau^i\right) - \dfrac{\mathcal{P}_k^i\left(\tau^i\right)}{\left(\tau^i\right)^{\gamma_k^i}}, \text{ with probability } 1-\mathcal{P}_k^j(\tau) \end{cases} \forall\ k \in K;\ i \in N, \tag{2.8}$$

which is subject to the following boundary conditions, associated with the requirement that the contract converges to the appropriate value at settlement

$$\mathcal{P}_k^i(0) = \begin{cases} 1, \text{ with probability } \mathcal{P}_k^i(1) \\ \\ 0, \text{ with probability } 1 - \mathcal{P}_k^i(1) \end{cases} \quad \forall\, k \in K;\ i \in N. \tag{2.9}$$

Equation (2.9) imposes the requirement that at settlement the jump size, conditional on being a winner, is $\left(1-\mathcal{P}_k^i(1)\right)$, while the losers experience a downward jump of magnitude $\mathcal{P}_k^i(1)$. The jump model also captures the conditional diverging volatility that is observed in the price dynamics of binary option markets, with the return variance from the underlying process being given by

$$\left\langle \left(\frac{\mathcal{P}_k^i\left((\tau-1)^i\right) - \mathcal{P}_k^j\left(\tau^i\right)}{\mathcal{P}_k^i\left(\tau^i\right)} \right)^2 \right\rangle = \left(\tau^i\right)^{-2\gamma_k^i} \left(\frac{1-\mathcal{P}_k^i\left(\tau^i\right)}{\mathcal{P}_k^i\left(\tau^i\right)} \right) \forall\, k \in K;\ i \in N. \tag{2.10}$$

Our object of interest, γ, is a strictly non-negative parameter that measures the rate at which the price process for the binary option contract converges to its terminal value, as specified by the boundary condition above. The movie market index variable, *i*, continues to be required at this stage of analysis because the model (γ^i) must be estimated (nonlinear least squares) separately for each of the 18 movie markets. We then individually test whether $\gamma^i = 1$, the value of the linear price convergence case. We leave for future research a joint test to assess whether, overall, the convergence parameter values differ from one. Similarly, the indicator, *k*, is still required, because we estimate the γ^i values separately for the two price series: γ_k^i.

In the second-stage of the methodology, we determine the relative impacts of the two components contributing to the impact of forecast errors on *ex post* realized returns: the magnitude and dispersion of the forecast error. The magnitude of the forecast error for movie *i* is captured by the difference between the *ex post* observed box office total for that movie, O^i, and the corresponding mean *ex ante* forecast of the box office total, f^i

$$\mu^i = \left(O^i - f^i\right). \tag{2.11}$$

The forecast dispersion or degree of disagreement is defined in a similar fashion

$$\sigma^i = \sqrt{\left(f^i - \mu^i\right)^2}. \tag{2.12}$$

For expositional simplicity, we will switch to vector-matrix notation for our discussion of the second-stage of the jump model. We identify potential non-scalars with upper-case Greek letters, while reserving lower-case Greek letters for identification of definite scalars (see Figure B2).

We pool the $\widehat{\gamma_k^j}$ values from the first-stage estimation and project (OLS) them onto a vector of ones and all possible combinations of the explanatory variables specified immediately above. Thus, the general form of our second-stage estimation procedure is

$$\Gamma = \alpha \mathrm{I} + \mathrm{XB} + \mathrm{E} \tag{2.13}$$

This projection allows us to test the absolute and relative impacts of μ^i and σ^i on γ_k^j.

Results

Replication

We follow Bondarenko and Bossaerts (2000) with respect to how we define variables when there is any discretion left to the researcher. Whenever contrasts are drawn between the results observed in our paper and those found by Bondarenko and Bossaerts, we are explicitly referring to those presented in their 2000 paper in which they studied WTA contracts (Microsoft ("MS") and Computer Industries ("CI") markets) from the IEM.

We perform all analyses on the daily closing prices for both price series, as detailed in (2.6). If we specifically want to highlight an aspect of the analysis which is of interest expressly because the results are dependent on *k*, we will refer directly to the appropriate price series. Otherwise, we will refer to our results collectively as "price," and, by implication, the return and modified return values derived from those prices.

We are now ready to discuss our results. Our sample consists of 3,538 pooled individual contract-day observations. Table A2 displays descriptive statistics for return, volume, and nonsynchrony measures across the 21 movies. We approach the issue of inference directly. We supplement the *t*-Statistics ("*t*-Stats") reported by Bondarenko and Bossaerts (2000), which are based on observed standard errors, with *z*-Statistics ("*z*-Stats"), which are based on standard errors derived from the empirical sampling distribution yielded by 100,000 bootstrap repetitions. These "robust" test methods are employed throughout the chapter, as documented in our Tables. Consistent with the evidence of a volatility smile in field markets, the distribution of returns in our movie markets is highly non-Gaussian, with severe right skewness and leptokurtosis. The kurtosis is also apparent in Table A3. Based on the non-Gaussian nature of the distribution of returns, Bondarenko and Bossaerts (2000) "punt" on the issue of inference altogether. In a footnote, they provide the following justification: "[w]e only report standard errors and whether the statistic is 1.8 or 2 standard errors from zero. In order to avoid unnecessary controversy, we refrain from attaching a specific p-level to the estimates. We allow the reader to use his or her favorite distributional theory to determine what the corresponding p-level is" (p. 1547).

The existence of nonsynchrony implies that closing prices, and, hence, returns, on complementary contracts do not necessarily sum to one. This is interesting because the IEM makes a “market” portfolio consisting of one unit of each traded contract in a particular market available for purchase or sale at a unit price at all times. We measure nonsynchrony as the average absolute deviation of the sum of the closing prices of complementary contracts from unity. Contract-day trading is more thin in our markets than it was in in the MS (65.6 less units) and CI markets (241.9 less units). Thus, it is not surprising that the average (0.162) and standard deviation nonsynchrony contract-day statistics observed in our markets are greater than those for the MS (0.006) and CI markets (0.019).

While Bondarenko and Bossaerts did not raise the issue in their 2000 paper, it is worth noting that the relationship between volume and nonsynchrony was far from direct in their case. The CI markets had almost 4-times more volume than did the MS markets, yet the CI markets had over 3 times higher nonsynchrony than did the MS markets. Therefore, it is certainly not clear that our relatively high levels of nonsynchrony are driven (primarily) by thin trading. That being said, Bondarenko and Bossaerts (2000) posit that the numbers observed in their markets are sizeable and, thus, conclude that nonsynchrony is a serious problem. To this extent, nonsynchrony will be an even more serious problem for us. This does not, however, necessarily imply that arbitrage opportunities were pervasive in our markets. The bid-ask spread may have been “sufficiently wide” to account for the lack of colinearity among returns on complementary contracts.

The lack of colinearity in returns of complementary contracts is even more apparent in Figure B3, which provides the price paths for winning contracts in each market. As normalized prices are perfectly synchronic, the market-by-market level of nonsynchrony can be ascertained visually from the deviation between the two price paths for a particular market. The price paths for the two series are virtually indistinguishable for the vast majority of contracts during the time period between the box office opening date and the final few days of the IEM market. The importance of the conditional diverging volatility aspect from (2.10) of the jump model is made clear by evidence that the large nonsynchrony values in Table A2 are being driven by the higher levels of volatility—that naturally accompany these periods of uncertainty for contracts with discontinuous price paths—near the open and close of each market.

We revisit the nonsynchrony issues below by examining the securities with payoffs complementary to those of the losing securities ("complements to losers" portfolio). Given our complete markets setting, the "complements to losers" portfolios are winners as well. These portfolios can be easily created easily by purchasing a bundle from the IEM for $1, and then immediately selling one of the component contracts. The price of this complementary security represents the value of the "complements to losers" portfolio.

If investors have beliefs that accord with RE, then returns should, on average, be zero. Conversely, if investors' actions accord with ELM but not with RE, then returns should be significantly positive and modified returns should be zero, on average. This would, thereby, imply that our investors rationally updated their priors via Bayes' law as information was revealed over time.

Per the ELM methodology, before starting our analysis, we first conditioned on the final outcome and removed the losers from our sample. This reduced our sample size to 771 total movie-day observations for the winning contracts in our 21 markets. Next, we averaged over the dimension for each winning contract, reducing our sample to one winning contract-level time-series average return for each of the 21 markets. This reflects the ELM's relative-time approach to analysis which focuses on drawing inferences at the cross-sectional level, after first collapsing across the time dimension of the sample through appeal to the mean ergodic theorem. In effect, the ELM relies on "large-N" asymptotics as opposed to traditional methods whose 'large T" asymptotics are sensitive to even slight deviations from stationarity.

In practice, the mean ergodic theorem merely requires movie-level observations to be free of cross-sectional correlation. No more than 2 of our markets, each of which involved its own distinct "market" portfolio, were in operation at the same time, so we can safely assume that our observations are cross-sectionally independent. Untabulated tests failed to reject cross-sectional independence in our data.

First, we averaged across the 21 collapsed movie-level observations to arrive at values for the daily return and modified return. We then tested whether this average was zero across the 21 (verified-independent) movie markets. At this point, our data consists of a cross-section of 21 averages for the IEM Movie Markets DGP. Table A3 displays the average of the time series daily return average, as well as its standard error. In all cases, the value is significantly different from 0 at the 1% level for the "complements to losers" portfolio constructed using normalized prices, and, otherwise, at the 5% level. Conversely, the average of the time series daily modified return average is insignificant in all cases. The results in Table A3 support Bossaerts' ELM because, while traders' began with incorrect forecasts, they rationally updated their forecasts over time.

In our remaining replication analyses, we analyze whether "predictability" tests are as supportive of the ELM as the "unbiasedness" tests in Table A3. The idea behind predictability tests is that, under RE, the return of winning securities ought to be unpredictable from any past information. We correlate the return and modified return with past information—the one-lag price and the square of the one-lag price—by taking the product of the return measure and the lagged-price measure: $r_{t+1}p_t(x_{t+1}p_t)$ and $r_{t+1}p_t^2(x_{t+1}p_t^2)$. We report the results from our ELM-based "predictability" test in Table A4 and those from our standard econometric tests in Tables A5 (winners) and A6 (winners and losers).

Table A4 reveals that, when correlated with the one-lag price, traditional returns were significantly different from zero at the 1% level. While modified returns, when correlated with the one-lag price, were insignificant for the normalized price series, they were significant at the 10% level for the *z*-Stat but not for the *t*-Stat for the unnormalized price series.

Our results for the square of the one-lag price were also a "mixed bag." On the one hand, the normalized price values continued to support the ELM, as traditional returns, when correlated with the square of the one-lag price, were significant at the 1% level, while the associated modified returns remained insignificant. On the other hand, the unnormalized price values series were now opposite to what was predicted by the ELM, as the correlated traditional return were insignificant, while their modified return counterparts were significant at the 5% level for both statistics.

In our standard econometric "predictability" tests, the results of which are presented in Tables A5 and A6, we follow Bondarenko and Bossaerts (2000) and limit our source of past information to the one-lag price. Instead of first "collapsing" across the time-series data as we did before, we now project the correlated values onto the one-lag price for the pooled collection of movie-day observations. In a private correspondence, Bossaerts acknowledged that they should have stuck to the ELM methodology because "it would have been better to run the tests the way we did in the IPO paper and insisted on cross-sections of monthly histories, as the properties of the statistical tests are better." Bossaerts and Hillion (2001) illustrate how regression-based predictability tests can be implemented in accordance with the ELM methodology. However, to faithfully represent their results, we proceed with the standard econometric methods in Tables A5 and A6.

In Table A5, we continue to consider only the 771 contract-day observations for winners. However, in Table A6, we shift our focus to a direct test of RE, and consider both winning and losing contracts. Thus, we employ all 3,538 contract-day observations in Table A6. Our standard econometric tests for Tables A5 and A6, confirm Bondarenko and Bossaerts' (2000) finding that residuals from projections of "plain" traditional returns and "plain" modified returns onto one-lag prices exhibit substantial heteroscedasticity. The variance of the residuals is especially high for low price levels.

We follow Bondarenko and Bossaerts (2000) in correcting for this heteroscedasticity by transforming our return measures via interaction with the respective one-lag price. We then use these transformed values in our projections. The resulting equations are of the form

$$r_{t+1}p_t = \alpha + \beta p_t + \varepsilon_t \qquad (2.14)$$

and

$$x_{t+1}p_t = \alpha + \beta p_t + \varepsilon_t. \qquad (2.15)$$

Note that, for the traditional return, this amounts to projecting the daily price change onto the one-lag price.

Our results from Table A5 are more favorable to the ELM than were those from Table A4. Both the intercept and the slope from (2.14) are significantly different from 0 at the 1% level for all specifications. While the slope from the modified return projections was insignificant for both price series, the *z*-Stat for the intercept from the normalized price series was significant at the 10% level, but the *t*-Stat remained insignificant.

We conclude the replication component of our analysis with a "predictive" regression test for RE. The test amounts to an unconditional version of (2.14), as we repeat the projection using our full sample of pooled winners and losers, using the same heteroskedasticity correction that we used for Table A5. As we are no longer conditioning on *ex post* knowledge of outcome status, we must limit our analysis to traditional returns. In this way, we can readily test the rationality of expectations by assessing whether past information can profitably be used in-sample to predict returns. This approach constitutes the empirical implementation of the (often unstated) imposed assumption that investors start with unbiased priors. The restriction is inevitably justified through appeal to RE even though RE *theory* neither requires nor implies that investors start with unbiased priors. Thus, the ELM methods are arguably more consistent with RE theory than are the standard econometric methods which appeal to it for their own justification.

Table A6 reports the results of our "predictability" tests for RE. Our results reject RE at high confidence levels, with all specifications proving significant at the 1% level. We also confirm Bondarenko and Bossaerts' (2000) findings of a positive intercept and a negative slope for this test, consistent with Keim and Stambaugh's (1986) observations for US stock returns.

Extension

Data limitations restrict our extension analyses to a subset of 18 of the 21 markets employed in the replication portion of our paper, as forecasts are not available for 3 of the markets: mat, sun, and tti. We include Hollywood Stock Exchange ("HSX") data in our analysis to provide a frame of reference for IEM traders' relative forecast errors, as expressed in the respective actual and absolute average mean forecast error values.

HSX data serves as a valuable benchmark for our IEM movie markets results. HSX results are based on conditional values, while the IEM results are based on unconditional values. Observed contrasts between the two series capture the dichotomy observed in field markets when using conditional values to test unconditional values. To this extent, our study actually benefits from the fact that the correspondence between the markets' forecast errors is imperfect.

HSX forecasts are made after opening weekend box office totals have been revealed. Consequently, HSX forecasts condition on a minimum of 14 days more information than IEM forecasts. Subsumed within this information set is the significantly informative opening weekend box office data. This first-weekend box office data is denoted as "open," while the four-week box office upon which official IEM payouts are determined is denoted as "total." To the extent that the unconditional IEM forecasts approach the conditional HSX forecasts in terms of "unbiasedness," the comparison will reflect favorably on the "quality" of IEM forecasts. Degree of disagreement measures are not available for HSX data because we do not have trader-level forecasts for the HSX. Analogously, the ratio measures of the forecast error to the standard deviation of the forecasts, μ^i/σ^i and $|\mu^i|/\sigma^i$, are not available for the HSX.

Table A7 reveals that the direction of errors in the IEM and HSX markets is similar. μ is underestimated for 10 (11) movies and overestimated for 8 (7) movies in the IEM and HSX markets, respectively. On average, the unconditional IEM error represented less than 12% of the average 4-week box office total, and the conditional HSX bias represented less than 2% of this total. Both average forecast errors are less than one standard error from the mean, as reflected in the IEM's small (0.45) ratio of the mean to the standard deviation. Similarly, in untabulated results, nonparametric sign tests fail to reject the null hypothesis that μ^i and $|\mu^i|$ are not completely random (p-values of 0.44 and 0.39, respectively).

Table A8 reports the γ_k^j values from the first-stage of our estimation process, along with the results of our *t*-Tests and *z*-Tests of the null hypothesis that γ_k^j = 1. 3 (6) of the unnormalized $\widehat{\gamma_k^j}$ values are greater than one, respectively. Based on *t*-Tests (*z*-Tests) 13 of these values are significantly different from one, 8 at the 1%, 3 at the 5%, and 2 at the 10% significance levels, respectively. No values that were significant under a *z*-Test failed to be significant under a *t*-Test. For the normalized price series, *t*-Tests indicate that 9 $\widehat{\gamma_k^j}$ values are significant (5 at the 1% significance level and 4 at the 5%

significance level, respectively), while *z*-Tests suggest that 12 of the values are significantly different from one (6 at the 1%, 4 at the 5%, and 2 at the 10% significance levels, respectively). 4 values are significant under *z*-Tests but not under *t*-Tests.

Three unnormalized values are significant when their normalized counterparts remain insignificant, whereas 6 normalized values are significant when their unnormalized counterparts are not significant. This contrast and the differing inferences yielded by the *z*-Tests for the normalized series, is likely a byproduct of the relatively small sample sizes used to estimate $\widehat{\gamma_k^j}$ from a (potentially) non-linear function. That being said, in untabulated *t*-Tests of the null hypothesis that γ equals one across the 18 γ values, we find no consistency between the $\widehat{\gamma_k^j}$ for the different elements of *k*: the normalized *t*-Stat is significant, while the unnormalized value is not.

Given these issues and our use of 100,000 bootstrap repetitions for the *z*-Tests, we are unable to draw any definitive conclusions about the magnitude of the actual rate of convergence for the underlying IEM Movie Market price series. Based solely on our results from Table A7, we are not able to assess the linearity of γ. Figure B4 presents a graph of the jump model process for one value from each of the 3 possible ranges for the parameter: (0,1), 1, and $(1,\infty)$. The graph illustrates how price convergence in the jump model depends on γ. On net, our results from Table A7 suggest that there is no systematic pattern in γ, as $\widehat{\gamma_k^j}$ is just as likely to be significantly different from one as it is to be equal to one.

Having collected out first-stage $\widehat{\gamma_k^j}$ estimates, we proceed with the second-stage of our econophysics analysis, (2.13), in Table A9. For the intercept terms in the projections, only 2 *t*-Stats are significant, while 4 *z*-Stats prove significant. Mean forecast error (actual or absolute value) is not significant either alone or in combination with other explanatory variables. The dispersion ("degree of disagreement") is also insignificant.

The ratio of mean bias to dispersion is significant at the 10% level according to the *t*-Stats. While the model with μ/σ and an intercept as the explanatory variables is jointly significant at the 10% level based on *F*-Stats, this significance goes away under the more robust *z*-Stats and Wald-χ^2 Statistics. Furthermore, when μ/σ is replaced by its absolute value, neither the intercept nor the ratio term is significant. Therefore, for the unnormalized price series, we conclude that the rate at which traders in both markets update is unaffected by either the magnitude of the forecast errors or the dispersion in those errors.

We report the results from our second-stage econophysics estimation for the normalized price series in Table A10. While not fully consistent with our findings for the unnormalized price series, our normalized results tend to support the conclusions reached in Table A9. The intercepts are significant, minimally at the 5% level, for all models, specifications, and markets. When included together, both μ and σ are significantly different from zero, but they remain insignificant in isolation or as a ratio. $|\mu|$ is significantly different from zero at the 5% level under *z*-Stats, but it remains insignificant under *t*-Stats. Both bias measures (actual and absolute value) remain insignificant in the HSX markets.

The normalized price series results from Table A10 tend to support our earlier conclusion: traders in both markets investors are neither underreacting nor overreacting to new information. Consistent with ELM, (but not RE) methods, the rate at which prices converge is statistically independent from the amount by which traders' forecasts are in error or by the degree of their disagreement. Thus, our jump model findings buttress the solid support for Bossaerts' ELM that we observed in our replication analysis.

Having completed our analyses, we pause to reflect on Bossaerts' three proposed extensions to tests of his ELM methodology (2004). Our findings confirm Bossaerts' hypothesized results. First, any apparent profitable trading rule is proven to be a mirage when tested with the more robust ELM methodology. Second, projections of out-of-sample returns onto forecasts lead to artificial evidence of predictability, but any such significance is reduced when using ELM methods. Third, the components of *ex post* average returns, demanded compensation for risk and incorrect forecasts, can be isolated and quantified. In particular, the magnitude of the difference between the RE and ELM methodologies represents the portion attributable to forecast error. This novel mechanism for quantifying the impact of various sample biases should be especially interesting to scholars of survivorship bias.

In this spirit, we reflect on our replication ad extension analyses in an attempt to consolidate the results, while drawing out underlying themes and common patterns across them. Our hope is that this brief synthesis will stimulate researchers to explore the ideas suggested by our work.

Concluding Remarks

We first confirm Bondarenko and Bossaerts' (2000) findings that evidence of return predictability suggested by standard econometric methods is illusory: it disappears when tested with robust ELM methods. We are then able to continue where they left off, due to the unique nature of our data set for which we have *ex ante* forecasts. Bondarenko and Bossaerts (2000) were limited to purely suggestive results based on the *deduction* that artificial evidence of return predictability must stem from trader updating of initially biased forecasts. We provide *analytical* evidence in support of their hypotheses regarding the nature of the forecast errors and the empirical superiority of the ELM methodology.

Our replication analyses reveal that traders rationally update in accordance with ELM even though, by starting with (known) biased priors, they violate RE. Our extension analyses lend additional support to the ELM, as we find that price convergence is efficient and independent of the magnitude and dispersion of initial forecast errors. Even though traders disagree about the distribution of expected final outcomes—and this distribution is not centered around the observed final outcome—markets nonetheless efficiently converge to the correct final outcome.

On net, our results provide strong support for the superiority of ELM empirical methods to existing methods which are based on appeals to RE. As such, we join

Bossaerts in arguing for the adoption of the ELM methodology, due to its less restrictive assumptions and robustness to sample biases. Our results also add to the literature documenting the persistence of market efficiency in the face of individual, trader-level biases.

Our findings suggest several interesting avenues for future research. Bossaerts and Hillion (2001) establish a connection between ELM test statistic values and the extent of investor overreaction or underreaction relative to Bayes' law. Overreaction (underreaction) to news leads to negative (positive) average modified returns on winning securities. These findings provide much-needed support to Bondaenko and Bossaerts' (2000) conclusions, which were largely tautological. Our test statistic values are not large, but it is interesting to note that they all shared the same negative sign. Thus, traders seem to *overreact* to new information, but not to a statistically significant extent. Bondarenko and Bossaerts (2000) document the exact same pattern. As Bondarenko and Bossaerts (2000) readily admit, by conditioning on contracts that are known to mature in the money, they expect to find positive returns under the RE methodology and negative correlation between modified returns and one-lag prices under the ELM methodology.

This is interesting in light of recent theoretical work by Ottaviani and Sørensen (2009), which shows that prices in binary prediction markets composed of traders with heterogeneous prior beliefs *underreact* to information when there is a bound to the amount of money traders are allowed to invest. This underreaction is increasing in price heterogeneity, and is followed by momentum resulting from price changes which are positively correlated over time.

Our and Bondarenko and Bossaerts' (2000) finding of overreaction contrasts with these theoretical predictions. This contradiction merits research consideration, but we leave the exploration to future work. Any such work will ideally be coupled with the jump model of Majumder et al. (2009), which provides complementary tests of overreaction/underreaction to information revealed over time. In aggregate, traders in our study do not consistently overreact or underreact to information. However, these patterns fluctuate widely on a market-by-market basis, and are at least partially dependent on the type of price series employed in the analysis. A joint overall test of whether the convergence parameters differ from one would be of interest. Hence, further research is warranted.

It would also be interesting to replicate our tests using Bossaerts and Hillion's (2001) more robust form of the ELM methodology discussed above. Similarly, our data would allow for a tatonnement-type analysis of the form implemented by Biais et al. (1999). Such an analysis would be a natural extension of the Bossaerts and Hillion (2001) approach, as they involve identical event-time relative alignment of the data and substantially similar statistical methods.

A final promising extension is suggested by Berg et al.'s (2009) analysis of data from prediction markets in which traders have limited experience with the underlying events that are to be predicted. Such markets include IPO and movie openings, akin to those studied in the present paper. The authors' methodology recognizes that any reasonable model of data generated in these environments must permit heterogeneity in trader forecast errors and allow forecasts to be revised in light of information revealed over the life of the market. Berg et al.'s. (2009) approach to constructing a cumulative distribution function from prediction market data allows researchers to produce more precise forecasts in the markets where they are needed most.

CHAPTER 3
IMPLICATIONS OF RATIONAL LEARNING IN FINANCIAL MARKETS

Introduction

In reviewing Bossaerts' book, *The Paradox of Asset Pricing* (*Paradox*), exactly one decade ago, Stephen LeRoy (2003) said the following:

> Five or ten years from now the book under review may well have dropped from sight, lost among the myriad of books and papers that propose novel research programs that turn out not to succeed empirically. However, another possibility—that this book will be seen as having a major impact on empirical study of financial markets and as generating valuable insights about security prices—seems to me to be more likely. I believe that Bossaerts' book is essential reading for economists who are serious about empirical study of security prices. More important, analysts need to develop the empirical methods Bossaerts has outlined and determine the extent of their applicability. (pp. 117-118)

With the benefit of hindsight (a qualification that is central to the analysis to follow), it appears that LeRoy was overly optimistic in his assessment. The methodology of *Efficiently Learning Markets* (ELM) that Bossaerts proposes in *Paradox* has not had a major impact on empirical asset pricing. However, as discussed herein, we contend that, before we can equate this with the assertion that the ELM has not succeeded empirically, the methodology must first actually be given a fair trial.

The present chapter grew out of discussions we have had over the years with a large number of peers and colleagues, as part of our circulation and presentation of the paper, "Divergence of opinion and convergence of prices in prediction markets" ("Divergence"), which serves as the second essay in this dissertation. We share LeRoy's enthusiasm for the ELM and were, thus, driven to do our part to give the methodology a fair trial by using it in "Divergence." While the feedback to the paper has been largely positive, most of the questions we have received are about the ELM itself rather than the novel extensions and analyses which are the focus of the work.

Before we conclude that the ELM has not generated valuable insights about asset pricing, we must first examine why it has not been widely adopted. This prompted us to create the present paper as a theoretical companion to "Divergence" for inclusion as the final essay in my dissertation. Our larger goal is to convince other researchers to give the ELM research program a second ("first") look. Based on the aforementioned questions we received about the ELM, the issues expressed by LeRoy in his review of *Paradox*, and numerous careful re-readings of the works by Bossaerts (and his co-authors) and the references therein which laid the framework for the ELM, we have isolated four key factors which we believe explain why our and LeRoy's enthusiasm for the ELM has not been shared by others.

First, early references to preliminary versions of what ultimately grew into the ELM can be found in working papers by Bossaerts and his co-authors which are dated at least as far back as 1996. Due to the vagaries of the publication process, published work in this regard did not appear in the most sensible chronological progression. In particular, many empirical applications of the ELM, as well as *Paradox*, were published years before the capstone methodological presentation of the ELM (2004). Bossaerts further complicated matters for his potential audience by changing his terminology and notation numerous times within and across iterations of papers.

Second, Bossaerts never decoupled his presentation of the ELM from his controversial stance on modern financial asset pricing, a radicalism suggested by his choice of title for his book: *The Paradox of Asset Pricing*. In particular, Bossaerts motivated the ELM on theoretical grounds that ran counter to modern financial theory, and it is not clear that adoption of the ELM did not imply acceptance of his theoretical reasoning. The ELM itself is entirely agnostic, and all of its assumptions are already being made under traditional empirical asset pricing.

Third, Bossaerts characterized the ELM as an alternative to the EMH. We believe that the ELM can most fruitfully be thought of as a complement to the EMH. All ELM assumptions are already being made as part of traditional, EMH-based econometric practice. Furthermore, Bossaerts' empirical results suggest that, if one finds an "apparent" return anomaly, he/she should take this same data and "run it through" the ELM. If the anomalous results persist, then they are truly anomalous. Otherwise, the results stemmed from biases, be they in investors' priors or in the data itself. Another way to conceptualize the ELM as a complement to the EMH is through consideration of Fama-Macbeth methods. In a traditional Fama-Macbeth framework, one obtains results from time-series regressions and then uses them as an input in cross-sectional regressions. One could implement the ELM by reversing the order and starting with cross-sectional regressions to achieve a "filtering" of the data. In the process, empiricists would be less prone to spurious results.

Fourth, the most radical, based on feedback over the years, aspect of the ELM is that it requires empiricists to use modified returns instead of returns computed in the traditional manner. The actual empirical differences are minute: one merely scales price increments by the end-of-period (*ex post*) price instead of the beginning-of-period (*ex-ante*) price. However, you cannot expect to change a precedent that has been entrenched through years of use and that appeals to conventional understanding of the concept of percentage change, without clearly explaining the need for and justification of such a change in detail. Unfortunately, Bossaerts does not provide such an explanation in his development of the ELM research program.

This paper has three objectives in providing clarifications for Bossaerts' (2004) original results. First, it explains why the use of modified returns is justified when testing for rational asset pricing restrictions using financial market data that are often subject to survivorship bias. Brown, Goetzmann, and Ross (1995) discuss the possibility of false rejection when analyzing historical price data collected from markets characterized by survivorship bias. For simplicity, the paper first analyzes the case of general limited liability securities. The analysis makes it clear that rational Bayesian updating by agents implies a restriction on weighted modified returns for a cross section of securities. This allows the researcher to test whether the market is efficient in the sense that agents update their beliefs (i.e., they learn) in a rational manner, even in data samples subject to survivorship bias. By contrast, as one cannot typically test whether the agents' initial beliefs (the 'priors') were unbiased, to test the more restrictive efficient markets hypothesis (EMH) with such data, we must make the additional restrictive assumption that prior beliefs were indeed correct.

Second, the paper confirms that the above results imply a testable restriction on the time series of a "winning" digital option's (inverse) prices. Third, the paper shows that testing in this framework is feasible using a GMM approach.

Before embarking on our analysis, we cite to a few more quotes from LeRoy's (2003) review of *Paradox*. We do this for two reasons: (1) to support our position that hesitation to employ the ELM methodology is likely to be driven at least as much by confusion about the justification for doing so as it is by perception that the methodology has nothing to offer, and (2) to prompt the reader to consider these important questions now, as we address each of them later in the paper.

LeRoy elaborates, noting that "Bossaerts proposes an ingenious econometric test of the hypothesis that agents price securities correctly in light of beliefs that display efficient learning, but not necessarily unbiased priors. The test will be valid even in the presence of selection biases of the type described in the preceding paragraph" (LeRoy, 2003, p. 123). Moreover, "[i]t happens that in this case we have the remarkable result that the conditional expectation of the inverse return equals 1 even if [the prior] does not equal [1]" (p. 125).

LeRoy's (2003) conclusion is the most telling aspect of his lingering confusion about the research design. He starts by noting that the ELM requires additional assumptions that he did not formally state in his review and acknowledges that "[t]he range of applicability of these assumptions is not clear, at least to this reviewer." In spite of this confusion, LeRoy (2003), nonetheless, proceeds to conclude that the ELM is very promising:

> On his own account Bossaerts has presented only a few preliminary results: application of these methods to the equity premium puzzle and other problems remains for the future. But Bossaerts is surely correct that this line of research is very promising. One hopes that he will continue work along these lines and that others will follow his lead. (p. 125)

The remainder of this paper is organized as follows. The second section introduces the formal theoretical justification for the empirical use of the ELM methodology. Emphasis is given to providing more intuitive and simplified proofs for the results. In the first part of the second section, we first establish the results for the case of general limited-liability securities. In the second part, we extend the results to the case of digital options. The third section establishes that the ELM restrictions naturally lend themselves to estimation and testing of asset pricing models (using modified returns) in the paradigmatic GMM framework. The fourth section concludes the paper.

Restatement of Bossaerts' (2004) Proof

As noted above, these results were originally derived by Bossaerts (2004). The following discussion is intended to provide additional clarifications so that the results may become accessible to a potentially wider audience.

Consider a two-period setting as depicted below. Trading occurs, and security (limited-liability securities in this case) prices are determined at the start of period 1 (indexed by date $t-1$) and at the start of period 2 (date *t*). Security payoffs, $\widetilde{V}$, are determined at the end of period 2, denoted *T**. The payoff at the end of period 2 may be viewed as a security's liquidation value (finite-life securities), or in case the security survives beyond *T**, as its value at *T** (perpetual-life securities).

General Case: Limited Liability Securities

Consider a limited-liability security with the following payoff structure at the end of period 2 (*T**):

$$V = \begin{cases} \widetilde{W}\,(>0) \\ 0 \end{cases}.$$

Note that the security's (random) payoff, $\widetilde{W}$, is strictly positive if the security does not default. Assume that all prices have been properly deflated using the appropriate stochastic discount factor. At date $t-1$, the security's price, P_{t-1}, reflects the market's prior belief (expectation) about what the security's terminal, liquidating payoff will be at *T**. Let $\Pr(V=\widetilde{W})$ denote the (arbitrary) prior probability that the security's (random) payoff at the end of the second period will be non-zero. Further, assume that the problem is a non-trivial one, in that $\Pr(V=\widetilde{W})>0$. No additional restrictions are imposed on the market's prior belief. For the remainder of the paper, we will use "belief" and "expectation" interchangeably

As depicted in Figure B5, at the end of period 1, and before trading takes place at date *t*, information arrives in the form of a signal, *S*. The information is generated by a binary stochastic process, which produces signals that take on one of two values, depending on whether the information is "good" or "bad" news: $S=0$ (signaling "bad" information about the terminal security payoff), or $S=1$ (signaling "good" information about the terminal security payoff). More specifically, the likelihood of receiving a good signal is higher than the likelihood of a bad signal, for securities that do not default: $\Pr(S=1|V=\widetilde{W})>\Pr(S=0|V=\widetilde{W})$. The market correctly (rationally) updates its prior belief in light of the information/signal and an updated clearing price, P_t, is determined at date *t*. In particular, upon receipt of the signal $(S=1, \text{or } S=0)$, the market updates its belief about whether a security's payoff would be positive. These are reflected in the following updated conditional probabilities:

$$\Pr\left(V=\widetilde{W}\middle|S=1\right)=\frac{\Pr\left(S=1\middle|V=\widetilde{W}\right)\Pr\left(V=\widetilde{W}\right)}{\Pr\left(S=1\middle|V=\widetilde{W}\right)\Pr\left(V=\widetilde{W}\right)+\Pr\left(S=1\middle|V=0\right)\Pr\left(V=0\right)}. \tag{3.1}$$

Similarly,

$$\Pr\left(V=\tilde{W}\middle|S=0\right) = \frac{\Pr\left(S=0\middle|V=\tilde{W}\right)\Pr\left(V=\tilde{W}\right)}{\Pr\left(S=0\middle|V=\tilde{W}\right)\Pr\left(V=\tilde{W}\right)+\Pr\left(S=0\middle|V=0\right)\Pr\left(V=0\right)}. \tag{3.2}$$

Claim: *Assuming that the market's expectation about the security payoffs in the non-default state is correct, then for a cross section of winning limited-liability securities (securities that do not default; they have a strictly positive liquidating payoff at T*), the average change in the ratio of final payoff to the security price is zero on average, i.e.,*

$$E\left\{\frac{\tilde{W}}{P_t}-\frac{\tilde{W}}{P_{t-1}}\middle|I_{t-1}\right\}=0.$$

Proof: First, note that, using the law of iterated expectations, we have,

$$\begin{aligned}E\left\{\frac{\widetilde{W}}{P_t}\middle|I_{t-1}\right\}&=E\left[E\left\{\frac{\widetilde{W}}{P_t}\middle|I_t\right\}\middle|I_{t-1}\right]=E\left[\left\{\frac{E\left(\widetilde{W}|I_t,S=.\right)}{E\left(\widetilde{W}|I_t,S=.\right)\Pr\left(V=\widetilde{W}|S=.\right)}\middle|I_{t-1}\right\}\right]\\&=E\left[\frac{1}{\Pr\left(V=\widetilde{W}|S=.\right)}\middle|I_{t-1}\right].\end{aligned} \tag{3.3}$$

Next, note that the conditional probability in the denominator in the above expression can be expressed as:

$$\Pr\left(V=\tilde{W}\,|\,S=.\right)=\Pr\left(V=\tilde{W}\,|\,S=1\right)\Pr\left(S=1\middle|V=\tilde{W}\right)$$
$$+\Pr\left(V=\tilde{W}\,|\,S=0\right)\Pr\left(S=0\middle|V=\tilde{W}\right).$$

Third, substituting the expressions for the conditional expectations given in equations (3.1) and (3.2) into the above expression yields:

$$E\left\{\frac{\tilde{W}}{P_t}\middle|I_{t-1}\right\}=E\left[\frac{1}{\Pr\left(V=\tilde{W}\,|\,S=.\right)}\middle|I_{t-1}\right]$$
$$=\frac{\left[\Pr\left(S=1\middle|V=\tilde{W}\right)\Pr\left(V=\tilde{W}\right)+\Pr\left(S=1\middle|V=0\right)\Pr\left(V=0\right)\right]}{\Pr\left(S=1\middle|V=\tilde{W}\right)\Pr\left(V=\tilde{W}\right)}\Pr\left(S=1\middle|V=\tilde{W}\right)$$
$$+\frac{\left[\Pr\left(S=0\middle|V=\tilde{W}\right)\Pr\left(V=\tilde{W}\right)+\Pr\left(S=0\middle|V=0\right)\Pr\left(V=0\right)\right]}{\Pr\left(S=0\middle|V=\tilde{W}\right)\Pr\left(V=\tilde{W}\right)}\Pr\left(S=0\middle|V=\tilde{W}\right).$$

The conditional probabilities in the respective numerator and the denominator of the two fractions above cancel out, so upon further simplification, we have,

$$E\left\{\frac{\tilde{W}}{P_t}\middle|I_{t-1}\right\}=\frac{\left[\Pr\left(S=1\middle|V=\tilde{W}\right)\Pr\left(V=\tilde{W}\right)+\Pr\left(S=1\middle|V=0\right)\Pr\left(V=0\right)\right]}{\Pr\left(V=\tilde{W}\right)}$$
$$+\frac{\left[\Pr\left(S=0\middle|V=\tilde{W}\right)\Pr\left(V=\tilde{W}\right)+\Pr\left(S=0\middle|V=0\right)\Pr\left(V=0\right)\right]}{\Pr\left(V=\tilde{W}\right)}$$

$$=\frac{\left[\Pr\left(S=1\right)\right]+\left[\Pr\left(S=0\right)\right]}{\Pr\left(V=\tilde{W}\right)}.$$

Valid probability measures must sum to one. Thus, we use the fact that the unconditional probabilities in the numerator of the above expression add up to one to observe that,

$$E\left\{\frac{\tilde{W}}{P_t}\middle| I_{t-1}\right\} = \frac{1}{\Pr\left(V = \tilde{W}\right)}. \tag{3.4}$$

Now consider the expected value of the ratio of the security payoff to its price at date $t-1$. We have,

$$E\left\{\frac{\tilde{W}}{P_{t-1}}\middle| I_{t-1}\right\} = \frac{E\left(\tilde{W}\middle| I_{t-1}\right)}{E\left(\tilde{W}\middle| I_{t-1}\right)\Pr\left(V = \tilde{W}\right)} = \frac{1}{\Pr\left(V = \tilde{W}\right)}. \tag{3.5}$$

By combining equations (3.4) and (3.5), we arrive at the desired result,

$$E\left\{\frac{\tilde{W}}{P_t} - \frac{\tilde{W}}{P_{t-1}}\middle| I_{t-1}\right\} = 0, \tag{3.6}$$

which proves the claim.

We effectuate a price transformation by multiplying through by $-P_{t-1}$ (which is not random, as it is known at time $t-1$) and collecting terms on $\tilde{W}$, thereby arriving at the following restatement of the result:

$$E\left[\left(\frac{P_t - P_{t-1}}{P_t}\right)\tilde{W}\middle| I_{t-1}\right] = 0. \tag{3.7}$$

In other words, the weighted *modified returns* on a cross section of limited-liability securities should be zero, on average. It merits noting that we are still using traditional returns. We are simply multiplying them by a scaling factor that filters them for any biases that may be present.

Equation (3.7) specifies a testable restriction on the modified returns for a cross section of limited-liability securities, weighted by the respective security payoffs. Also, note that, as $\tilde{W} = 0$ for securities that were subject to default, the above restriction holds for a subset of "winning" securities. Hence, the restriction may be tested on samples (of securities) subject to a survivorship bias.

Special Case: Digital Options

Now consider the case of digital options of the Arrow-Debreu contingent claim variety, which have the following payoff structure at the end of the second period:

$$V = \begin{cases} 1, \\ 0 \end{cases}.$$

Note that, with the above payoff structure, the security payoff at *T** is not random for the case of "winning" digital options, those digital options that expire "in the money;" they have a strictly positive liquidating payoff (1) at *T**. In this case, a security that "defaults" is one that expires "out of the money." Now, the only source of randomness is the security's "moneyness" status at the end of period 2, as conditional on said "moneyness" status, the security's payoff is fixed at 1 (in the money) or 0 (out of the money). In other words, conditional on the information that the option expired in the money, the final payoff is known, and is equal to 1. The derivation of the previous result is, thus, simplified for the case of digital options, because we are able to condition on the "winning" security's actual payoff and appeal to conditional independence. Furthermore, in this special case, we are able to derive a restriction on the time series of (inverse) prices of an individual security (digital option). To see this, substitute $\tilde{W} = 1$ in equations (3.4) and (3.5) and take the difference, which immediately yields the following result:

$$E\left\{\frac{1}{P_t}-\frac{1}{P_{t-1}}\middle| I_{t-1}\right\}=0\,. \tag{3.8}$$

Equation (3.8) provides a testable restriction on a time series of a "winning" digital option's (inverse) prices. Bossaerts (2004) restates the above restriction in the form of modified returns, as

$$E\left[\left(\frac{P_t-P_{t-1}}{P_t}\right)\middle| I_{t-1},\tilde{W}=1\right]=0. \tag{3.9}$$

Note that no explicit weighting of the modified returns is required for the case of digital options. However, the weighting is present, nonetheless, due to an implicit weighting by 1.

Testing

An appealing feature of the methodology proposed by Bossaerts (2004) is that asset pricing restrictions such as those specified in Equations (3.7) and (3.9) may be tested on samples subject to survivorship bias—a common feature of financial datasets. Essentially, by transforming price data and using (weighted) modified returns, researchers are able to filter out the bias that afflicts traditional returns in such cases.

Consider, for example, the restriction on winning digital options, specified in Equation (3.9). In the derivation above, it was assumed that the modified returns were calculated from the appropriately deflated prices. However, to make this more explicit, consider a candidate stochastic discount factor, m_t, and let the modified return be based on the raw (non-deflated) security prices. The restriction in Equation (3.9) may then be expressed as:

$$E\left[m_t x_t \middle| I_{t-1}, \tilde{W}=1\right]=0, \tag{3.10}$$

where $x_t = [(P_t - P_{t-1})/P_t]$ represents the modified return.

The parameters of the stochastic discount factor can be estimated and the above restriction may be tested using data on (weighted) modified returns of winning digital options using Hansen's (1982) GMM framework.

Concluding Remarks

Standard methods employed in empirical asset pricing require researchers to test models in conjunction with the assumption that (prior) market beliefs are correct. Rejections of tested models suggest the existence of a pricing anomaly.

Bossaerts (2004), instead, argues that rationality is a characteristic of learning. As a result, the market should be allowed a biased prior belief, so long as it uses Bayesian learning to update its beliefs on the basis of the correct likelihood of information. This point of view leads to a different way to investigate asset pricing models, one that is consistent with allowing the market to have incorrect beliefs about some or all parameters of the economy. In particular, the market's subjective assessment of the future is allowed to differ from the objective probability distribution. Market participants are, nonetheless, assumed to be rational learners.

The GMM methodology familiar to modern asset pricing empiricists accommodates Bossaerts' view. A set of novel rationality (martingale) restrictions on securities prices that are robust to investors' initial beliefs persists even under the relaxed assumption of rational learning. In particular, the moment conditions apply to (weighted) modified returns. Unlike traditional returns, which use the previous price as the basis, modified returns use the future (deflated) price as the basis. By altering the denominator used in the return measure (price transformation) employed to test asset pricing models, researchers are effectively able to "filter" the examined price data for any biases in the market's prior.

These moment conditions obtain for prices of limited-liability securities whose payoff can be categorized into two states: "winner" or "loser." The most general (and important) example of such a limited liability security is equity. Digital options, especially those that pay 1 in some states of the world and 0 in others—the Arrow-Debreu variety—are particularly simple examples of such securities. Importantly, Bossaerts' restrictions not only hold when market beliefs are mistaken, but they also can be tested in samples affected by selection biases. Thus, the methodology provides researchers with a way to determine whether "observed anomalies" are real or merely a byproduct of biased tests and their associated return measures.

The present paper has elucidated why the use of modified returns is justified when testing for rational asset pricing restrictions. It also demonstrates how and why Bossaerts' results extend beyond the case of digital options to general limited-liability securities, including equities. Finally, the paper shows that ELM restrictions naturally lend themselves to estimation and testing of asset pricing models, using weighted modified returns, in a GMM framework.

APPENDIX A
TABLES

Table A1. Market Data

iem open	box office open	revelation	iem close	number of econophysics observations	mnemonic	number of contracts
03/27/1998	04/03/1998		04/30/1998	32	lis	4
03/27/1998	04/031/1998		04/3019/98	32	mr	4
11/09/1998	11/13/1998		12/1019/98	31	isk	4
11/09/1998	11/20/1998		12/17/1998	38	eos	5
03/24/1999	03/31/1999	04/07/1999	04/29/1999	0	mat	4
03/24/1999	03/31/1999	04/11/1999	04/29/1999	0	tti	4
11/05/1999	11/19/1999		12/16/1999	40	sh	5
11/05/1999	11/19/1999	12/14/1999	12/16/1999	40	wine	5
11/03/2000	11/17/2000		12/14/2000	39	six	4
11/03/2000	11/17/2000		12/14/2000	39	grin	4
10/19/2001	11/02/2001	11/24/2001	11/29/2001	38	minc	5
11/02/2001	11/16/2001	12/10/2001	12/13/2001	41	hps	5
11/08/2002	11/22/2002	12/08/2002	12/19/2002	41	die	5
11/07/2003	11/21/2003		12/18/2003	40	cat	6
02/20/2003	03/07/2003		04/03/2003	0	sun	4
11/05/2004	11/19/2004		12/17/2004	39	sbob	6
11/03/1906	11/22/2006		12/21/2006	46	font	5
11/03/2006	11/17/2006	11/25/2000	12/15/2006	39	hfet	5
02/23/2007	03/09/2007	03/16/2007	04/05/2007	39	thre	5
11/02/2007	11/16/2007		11/13/2007	40	beow	5
11/11/2008	11/21/2008	12/06/2008	12/18/2008	36	twlt	6

The “iem open” heading refers to the date that the IEM Movie Markets opened for that movie. The “box office open” heading refers to the date that the movie opened at the box office in the U.S. Heading “revelation” refers to the date that the outcome was determined (state was realized), if that realization occurred prior to the “iem close,” the date that the IEM Movie Markets closed for that movie. The “number of econophysics observations” refers to the number of non-missing values available for the winning contract for that movie—if this value is zero, then we do not have forecasts for that movie. The “mnemonic” is the IEM-specified abbreviation for that movie. We refer to markets by their “abbreviation” throughout the paper. Appendix E details movie names, along with their assigned mnemonics. And “contracts” refers to the number of contracts (discrete segments of the underlying continuous outcome space) for that movie at the time of its opening in the IEM Movie Markets.

Table A2. Descriptive Statistics

		Price	
		unnormalized	normalized
N		3538	3538
Daily return	Average	0.862	0.741
	St. dev.	9.313	7.404
	Skewness	21.3	18.9
	Kurtosis	557	443
Average daily volume (Units)		14.4	14.4
Measure of nonsynchrony	Average	0.162	0.000
	St. dev.	0.210	0.000

The information is based on daily closing prices from the Iowa Electronic Markets for 21 movie markets held intermittently over the 129-month period from March 27, 1998 to December 18, 2008. The closing price is the price of the last transaction or, if no transaction took place during the day, the previous closing price. N denotes sample size. Nonsynchrony is measured by the average absolute deviation of the sum of the closing prices of complementary contracts from unity. The unnormalized prices are the actual prices collected from the Iowa Electronic Markets. The normalized prices are the relative prices of the respective states (possible box office outcomes represented by the mutually exclusive and collectively exhaustive contracts offered in each market). They are obtained on a movie-by-movie basis by dividing a contract's price by the sum of the market prices of all contracts in that same market (including the contract being normalized) for all dates under study.

Table A3. Analysis of Payoffs on Winning Contracts

				Price	
				unnormalized	normalized
Winners					
	N			21	21
	$\bar{r}$	Average		0.299	0.216
				(0.146)	(0.089)
			t-Stat	2.05**	2.43**
			z-Stat	2.10**	2.49**
		Skewness		3.3	3.1
		Kurtosis		13.1	12.0
	$\bar{x}$	Average		-0.107	-0.049
				(0.067)	(0.032)
			t-Stat	-1.60	-1.52
			z-Stat	-1.64	-1.55
		Skewness		-3.3	-2.0
		Kurtosis		13.4	5.8
Complements to losers					
	N			79	79
	$\bar{r}$	Average		0.053	0.015
				(0.021)	(0.003)
			t-Stat	2.53**	5.19**
			z-Stat	2.54**	5.22**
		Skewness		6.4	3.4
		Kurtosis		47.2	14.7
	$\bar{x}$	Average		-0.069	-0.002
				(0.044)	(0.002)
			t-Stat	-1.58	-1.08
			z-Stat	-1.59	-1.08
		Skewness		-6.0	-4.0
		Kurtosis		38.0	20.6

N, unnormalized prices, and normalized prices are defined in Tables A1 and A2 and the text. $\bar{r}$ is the average across all movie markets of time-series average daily traditional return. $\bar{x}$ is the the average across all movie markets of time-series average daily modified return, where payoff is divided by end-of-period closing price. Standard errors are in parentheses. *t*-Statistics are based on observed standard errors. *z*-Statistics are based on standard errors derived from empirical sampling distribution yielded by 100,000 bootstrap repetitions. Significance of *t*-Statistics is determined with respect to the *t*-distribution. Significance of *z*-Statistics is determined with respect to the *z*-distribution (asymptotic-Gaussian). *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. The closing prices of complements to losers are obtained by subtracting the closing price of a loser from the price at which the market portfolio can be bought from the system (i.e., $1). The price history of the complements to losers is not identical to that of the winners, because of nonsynchrony.

Table A4. Analysis of Payoffs on Winning Contracts: Correlation with Lagged Information

			Price	
			unnormalized	normalized
Lagged price				
	N		21	21
	$\overline{rp}$	Average	0.016	0.017
			(0.001)	(0.001)
	t-Stat		10.84***	14.37***
	z-Stat		11.08***	14.70***
		Skewness	-0.6	-0.6
		Kurtosis	3.6	2.4
	$\overline{xp}$	Average	-0.055	-0.016
			(0.031)	(0.011)
	t-Stat		-1.77	-1.51
	z-Stat		-1.80*	-1.55
		Skewness	-3.7	-2.3
		Kurtosis	16.1	7.1
Lagged price squared				
			21	21
	$\overline{rp^2}$	Average	-0.001	0.005
			(0.002)	(0.001)
	t-Stat		-0.29	3.29***
	z-Stat		-0.30	3.35***
		Skewness	-1.7	-1.8
		Kurtosis	6.4	6
	$\overline{xp^2}$	Average	-0.037	-0.009
			(0.018)	(0.006)
	t-Stat		-2.07**	-1.45
	z-Stat		-2.10**	-1.48
		Skewness	-3.4	-2.7
		Kurtosis	14.3	9.4

N, unnormalized prices, and normalized prices are defined in Tables A1 and A2 and the text. $\overline{rp}$ is the average across all movie markets of the time-series average daily traditional return multiplied by the lagged price level. $\overline{xp}$ is the average across all movie markets of the time-series average daily modified return multiplied by the lagged price level. $\overline{rp^2}$ is the average across all movie markets of the time-series average daily traditional return multiplied by the square of the lagged price level. $\overline{xp^2}$ is the average across all movie markets of the time-series average daily modified return multiplied by the square of the lagged price level. Standard errors are in parentheses. t-Statistics and z-Statistics are obtained as explained in Table A3. Standard errors and significance levels are handled as explained in Table A3. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table A5. Analysis of Payoffs on Winning Contracts: OLS Projections of Returns Times Lagged Prices onto Lagged Price Levels

	Return		Modified Return	
	unnormalized	normalized	unnormalized	normalized
N	771	771	771	771
Intercept	0.069	0.044	-0.041	-0.023*
	(0.010)	(0.007)	(0.044)	(0.017)
t-Stat	6.77***	6.08***	-0.94	-1.35
z-Stat	6.04***	5.79***	-1.00	-1.95
Slope	-0.086	-0.046	-0.027	0.009
	(0.014)	(0.011)	(0.063)	(0.025)
t-Stat	-5.99***	-4.28***	-0.43	0.35
z-Stat	-5.75***	-4.96***	-0.53	0.62
R^2	0.045	0.023	0.000	0.000

N , unnormalized prices, and normalized prices are defined in Tables A1 and A2 and the text. To compute the modified return, the payoff is divided by the end-of-period price. The standard return times the lagged price level is identical to the price change. Returns are multiplied by the lagged price level in order to mitigate heteroscedasticity. Standard errors are in parentheses. *t*-Statistics and z-Statistics are obtained as explained in Table A3. Standard errors and significance levels are handled as explained in Table A3. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table A6. OLS Projections of Daily Changes in Prices onto Lagged Price Levels

	Price	
	unnormalized	normalized
N	3538	3538
Intercept	0.011	0.005
	(0.002)	(0.002)
t-Stat	4.84***	2.84***
z-Stat	6.34***	3.88***
Slope	-0.055	-0.023
	(0.006)	(0.005)
t-Stat	-8.86***	-4.73***
z-Stat	-6.92***	-4.53***
R^2	0.022	0.006

N , unnormalized prices, and normalized prices are defined in Tables A1 and A2 and the text. To compute the modified return, the payoff is divided by the end-of-period price. The standard return times the lagged price level is identical to the price change. Returns are multiplied by the lagged price level in order to mitigate heteroscedasticity. Standard errors are in parentheses. *t*-Statistics and *z*-Statistics are obtained as explained in Table A3. Standard errors and significance levels are handled as explained in Table A3. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table A7. Forecast Error Distributions: *Ex Ante* Predictions vs. *Ex Post* Outcomes

	Box office		IEM forecasts				HSX forecasts	
movie	open	total	Mean	μ	Σ	$\frac{\mu}{\sigma}$	mean	μ-HSX
beow	27.52	77.80	114.31	36.51	64.83	-0.56	74.29	-3.51
cat	38.33	91.60	184.41	92.81	91.02	-1.02	103.49	11.89
die	47.07	134.40	115.90	-18.50	18.77	0.99	127.09	-7.31
eos	20.04	74.40	99.01	24.65	52.94	-0.46	54.10	-20.25
font	3.77	9.90	41.59	31.71	33.84	-0.94	7.54	-2.34
grin	55.08	199.80	104.49	-95.34	30.22	3.15	148.72	-51.11
hfet	41.53	140.90	121.14	-19.75	52.06	0.38	112.14	-28.75
hps	90.29	234.40	205.19	-38.16	56.15	0.52	243.80	0.45
isk	16.52	36.40	50.39	14.04	24.54	-0.57	44.60	8.84
lis	20.15	59.10	48.29	-10.78	22.12	0.49	54.42	-4.65
minc	62.58	194.90	123.51	-71.42	38.10	1.87	168.96	-25.97
mr	10.10	28.50	32.81	4.27	13.10	-0.33	27.28	-1.26
sbob	32.02	74.30	91.30	17.00	38.39	-0.44	86.45	12.15
sh	30.06	82.90	53.33	-29.59	22.50	1.31	81.16	-1.76
six	13.02	33.40	68.60	35.16	21.41	-1.64	35.16	47.72
thre	70.89	185.00	78.71	-106.32	35.85	2.96	191.39	6.36
twlt	69.64	153.00	73.50	-79.50	39.16	2.03	69.64	35.02
wine	35.52	101.30	93.38	-7.96	29.00	0.27	95.90	-5.44

For the IEM, the mean forecast error, denoted by μ, represents the magnitude of the bias in the IEM market's prior, as expressed in the mean forecast. Similarly, for the Hollywood Stock Exchange ("HSX"), which is included in the analysis to provide a frame of reference for the relative bias in IEM investors' priors, the mean forecast error, denoted by μ-HSX, represents the magnitude of the bias in the HSX market's prior, as expressed in the mean forecast. However, as discussed in more detail in the body of the paper, the correspondence between the two market forecasts/biases is imperfect, as HSX forecasts are made after opening weekend box office totals have been revealed. Consequently, HSX forecasts condition on a minimum of 14 days more information than IEM forecasts, and subsumed within this information set is the significantly informative opening weekend box office data. This first-weekend box office data is denoted as "open," while the four-week box office upon which official IEM payouts are determined is denoted as "total." To the extent that IEM forecasts approach HSX forecasts in terms of "unbiasedness," the comparison will reflect favorably on the "quality" of IEM forecasts. For the IEM, the degree of disagreement in the forecasts at the individual movie-level, denoted by σ, represents the magnitude of the dispersion in the investor-level forecasts that comprise the market's prior. This data is not available for the HSX. Analogously, μ/σ represents the ratio of the forecast error (bias) to the standard deviation of the forecasts. Again, no comparison is available with regard to the HSX, as the forecast standard deviation data is not available. In anticipation of our second-stage estimation of the dynamic binary option model, we note that we have provided sufficient information in this table to calculate μ and μ/σ, as these two measures merely involve taking the absolute value of statistics provided in the table. In this analysis, we are limited to the consideration of only a subset (18) of the total number (21) of markets used in our earlier analysis, because *ex ante* price forecasts are not available for 3 of the markets: mat, sun, and tti. All dollar amounts are expressed in $ millions.

Table A8. Stage-one of the Dynamic Binary Option Model: Estimation of the Speed of Convergence Parameter (γ) Via Nonlinear Least Squares

		Price								
		unnormalized					normalized			
Movie	γ	t-Stat		z-Stat		Γ	t-Stat		z-Stat	
beow	0.300	-264.36***	(0.000)	-67.89***	(0.000)	0.538	-62.51***	(0.000)	-25.33***	(0.000)
cat	0.815	-5.33**	(0.026)	-3.35*	(0.067)	0.996	-0.00	(0.971)	-0.00	(0.989)
die	0.681	-7.04**	(0.012)	-2.36	(0.125)	0.748	-4.08**	(0.050)	-0.34	(0.681)
eos	0.458	-97.37***	(0.000)	-44.41***	(0.000)	0.615	-22.95***	(0.000)	-7.21***	(0.000)
font	0.675	-34.15***	(0.000)	-11.73***	(0.001)	0.733	-29.12***	(0.000)	-16.63***	(0.000)
grin	1.658	1.79	(0.186)	0.82	(0.366)	0.759	-6.34**	(0.016)	-2.74*	(0.084)
hfet	0.603	-34.21***	(0.000)	-12.23***	(0.000)	0.886	-1.03	(0.316)	-0.21	(0.508)
hps	0.766	-3.37*	(0.074)	-1.17	(0.279)	6.188	0.01	(0.909)	9.92***	(0.000)
isk	1.384	1.09	(0.304)	0.38	(0.538)	7.609	0.09	(0.763)	5.74**	(0.017)
lis	0.982	-0.01	(0.906)	-0.00	(0.966)	6.200	0.00	(0.947)	4.89**	(0.024)
minc	0.824	-2.38	(0.132)	-0.64	(0.423)	2.949	1.00	(0.325)	2.65*	(0.089)
mr	1.020	0.01	(0.921)	0.00	(0.947)	1.304	1.10	(0.302)	0.28	(0.566)
sbob	0.605	-42.90***	(0.000)	-14.88***	(0.000)	0.809	-6.57**	(0.015)	-3.55**	(0.049)
sh	0.842	-3.29*	(0.077)	-0.55	(0.460)	0.677	-37.69***	(0.000)	-14.78***	(0.000)
six	0.605	-29.93***	(0.000)	-8.08***	(0.004)	1.253	0.89	(0.352)	0.24	(0.535)
thre	0.633	-15.77***	(0.000)	-0.90	(0.344)	0.826	-2.79	(0.103)	-0.17	(0.649)
twlt	0.495	-70.71***	(0.000)	-36.89***	(0.000)	0.695	-26.86***	(0.000)	-23.64***	(0.000)
wine	0.821	-4.13**	(0.049)	-2.59	(0.108)	0.829	-5.48**	(0.025)	-3.73**	(0.047)

The unnormalized prices and normalized prices are defined in Tables A1 and A2 and the text. To compute the modified return, the payoff is divided by the end-of-period price. μ is obtained by nonlinear least squares estimation of the piecewise-defined function for the martingale price process. Standard errors are in parentheses. In accordance with the ELM methodology, we consider only winning contracts. In our analysis of the dynamic binary option model, we are limited to the consideration of only a subset (18) of the total number (21) of markets used in our earlier analysis, because *ex ante* price forecasts are not available for 3 of the markets: mat, sun, and tti. The null hypothesis being tested is that $\gamma = 1$; i.e., that the convergence rate is linear. As such, convergence parameter values less than one result in negative t-Statistics. Standard errors are in parentheses. t-Statistics and z-Statistics are obtained as explained in Table A3. Standard errors and significance levels are handled as explained in Table A3. *, **, and *** indicate that the corresponding test statistic is significant at the 10%, 5%, and 1% level, respectively.

Table A9. Stage-two of the Dynamic Binary Option Model: OLS Projections of Estimated γ Values onto Variables from the Distribution of Forecasts Using Unnormalized Prices

					Model				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
intercept	3.556	1.209	5.463	6.030	8.557	5.246	6.664	3.029	-0.334
	(1.54)	(0.32)	(1.86)*	(1.64)	(1.60)	(0.91)	(1.27)	(1.31)	(-0.09)
	[1.94]*	[0.33]	[1.80]*	[1.59]	[1.45]	[0.88]	[1.11]	[1.96]**	[-0.11]
μ	0.073					0.067			
	(1.62)					(1.33)			
	[1.39]					[1.08]			
$\lvert\mu\rvert$		0.080					0.121		
		(1.09)					(1.59)		
		[0.85]					[1.19]		
μ-HSX			-0.083						
			(-0.50)						
			[-0.60]						
$\lvert\mu\text{-HSX}\rvert$				-0.095					
				(-0.46)					
				[-0.71]					
σ					-0.109	-0.043	-0.188		
					(-0.87)	(-0.32)	(-1.45)		
					[-0.94]	[-0.31]	[-1.45]		
$\frac{\mu}{\sigma}$								3.106	
								(1.89)*	
								[1.56]	
$\left\lvert\frac{\mu}{\sigma}\right\rvert$									4.28
									(1.65)
									[1.27]
F-Stat	2.61	1.19	0.25	0.21	0.75	1.28	1.68	3.56*	2.72
	(0.126)	(0.291)	(0.623)	(0.652)	(0.399)	(0.306)	(0.219)	(0.077)	(0.118)
Wald-χ^2	1.93	0.72	0.37	0.50	0.89	1.54	2.58	2.45	1.55
	[0.164]	[0.397]	[0.545]	[0.479]	[0.345]	[0.462]	[0.276]	[0.118]	[0.213]
R^2	0.140	0.069	0.018	0.015	0.045	0.146	0.183	0.182	0.145
N	18	18	18	18	18	18	18	18	18

The unnormalized prices are defined in Tables A1 and A2 and the text. μ, $\lvert\mu\rvert$, μ-HSX, $\lvert\mu\text{-HSX}\rvert$, μ/σ, and $\lvert\mu/\sigma\rvert$ defined in Table A7 and the text, and their values are in Table A7. We consider only winning contracts. Standard errors are in parentheses and square brackets. t-Statistics and z-Statistics are obtained as explained in Table A3. Standard errors and significance levels are handled as explained in Table A3. The standard errors for the associated F-Statistics (Wald-χ^2-Statistics), are in parentheses (brackets), respectively. *, **, and *** indicate that the corresponding test statistic is significant at the 10%, 5%, and 1% level, respectively.

Table A10. Stage-two of the Dynamic Binary Option Model: OLS Projections of Estimated γ Values onto Variables from the Distribution of Forecasts Using Normalized Prices

	Model								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
intercept	9.591	14.451	10.856	11.810	16.234	21.188	17.962	10.170	11.802
	(3.27)***	(3.30)***	(3.13)***	(2.69)**	(2.57)**	(3.22)***	(2.81)**	(3.46)***	(2.51)**
	[3.06]***	[3.12]***	[2.94]***	[2.51]**	[2.36]**	[2.51]***	[2.25]**	[3.28]***	[2.71]***
μ	-0.058					-0.010			
	(-1.02)					(-1.75)*			
	[-1.15]					[-2.07]**			
$\lvert\mu\rvert$		-0.138					-0.111		
		(-1.62)					(-1.19)		
		[-2.30]**					[-1.64]		
μ-HSX			-0.182						
			(-0.93)						
			[-1.02]						
$\lvert\mu\text{-HSX}\rvert$				-0.185					
				(-0.75)					
				[-0.73]					
σ					-0.193	-0.292	-0.121		
					(-1.30)	(-1.93)*	(-0.76)		
					[-1.38]	[-1.78]*	[-0.77]		
$\frac{\mu}{\sigma}$								-2.843	
								(-1.36)	
								[-1.58]	
$\lvert\frac{\mu}{\sigma}\rvert$									-2.614
									(-0.78)
									[-0.92]
F-Stat	1.05	2.63	0.87	0.56	1.68	2.48	1.57	1.84	0.61
	(0.322)	(0.125)	(0.367)	(0.466)	(0.214)	(0.117)	(0.241)	(0.193)	(0.446)
Wald-χ^2	1.32	5.27**	1.04	0.53	1.91	5.00*	3.53	2.50	0.85
	[0.250]	[0.022]	[0.307]	[0.466]	[0.167]	[0.082]	[0.171]	[0.114]	[0.357]
R^2	0.061	0.141	0.059	0.039	0.095	0.249	0.173	0.103	0.037
N	18	18	18	18	18	18	18	18	18

The normalized prices are defined in Tables A1 and A2 and the text. μ, $\lvert\mu\rvert$, μ-HSX, $\lvert\mu\text{-HSX}\rvert$, μ/σ, and $\lvert\mu/\sigma\rvert$ defined in Table A7 and the text, and their values are in Table A7. We consider only winning contracts. Standard errors are in parentheses and square brackets. t-Statistics and z-Statistics are obtained as explained in Table A3. Standard errors and significance levels are handled as explained in Table A3. The standard errors for the associated F-Statistics (Wald-χ^2-Statistics), are in parentheses (brackets), respectively. *, **, and *** indicate that the corresponding test statistic is significant at the 10%, 5%, and 1% level, respectively.

APPENDIX B
FIGURES

Figure B1. Movie Market Timeline

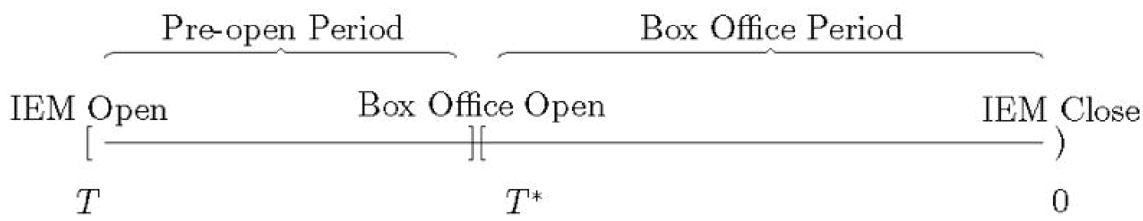


Figure B2. Vector-matrix Notation for the Second-stage of the Jump Model

Γ		The (18×1) vector of stacked $\widehat{\gamma}_i^{\,s}$ from the Stage 1 estimation
I		An (18×1) vector of ones (1^s)
X		The matrix of explanatory variables in the Stage 2 projection
	Specification 1	An (18×1) vector
	μ_i	
	$\lvert\mu_i\rvert$	
	μ-HSX$_i$	
	$\lvert\mu\text{-HSX}_i\rvert$	
	σ_i	
	$\frac{\mu_i}{\sigma_i}$	
	$\left\lvert\frac{\mu_i}{\sigma_i}\right\rvert$	
	Specification 2	An (18×2) matrix
	μ_i and σ_i	
	$\lvert\mu_i\rvert$ and σ_i	
α		The (scalar) estimate from a particular projection specification
B		The scalar/vector of slope (β) estimate(s)
E		The (18×1) vector of error terms $("\varepsilon_i^{\,s}")$

Figure B3. Time-series Plots of Both Unnormalized and Normalized Daily Closing Prices for Winning Contracts

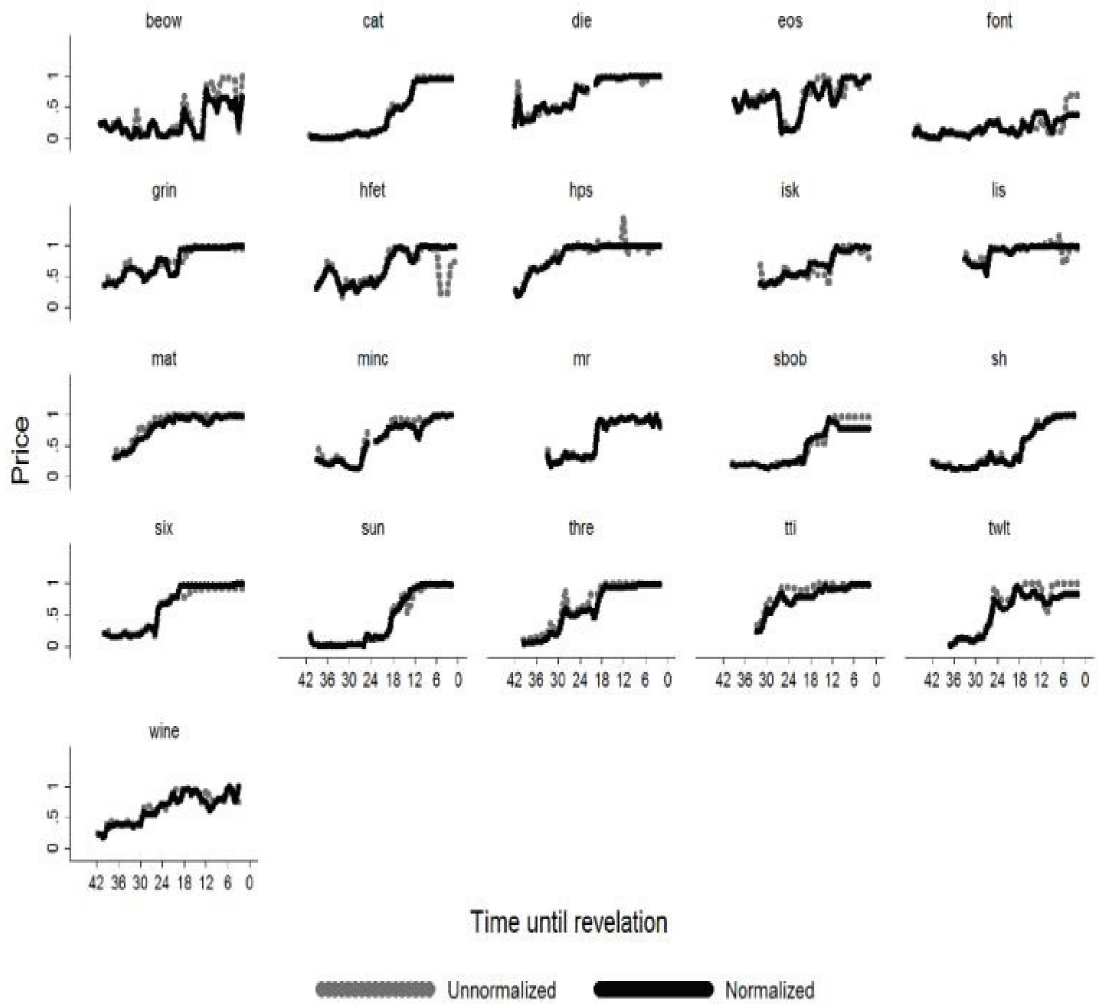


Figure B4. Depiction of the Dynamic Binary Option Model Price Process: The Role of γ

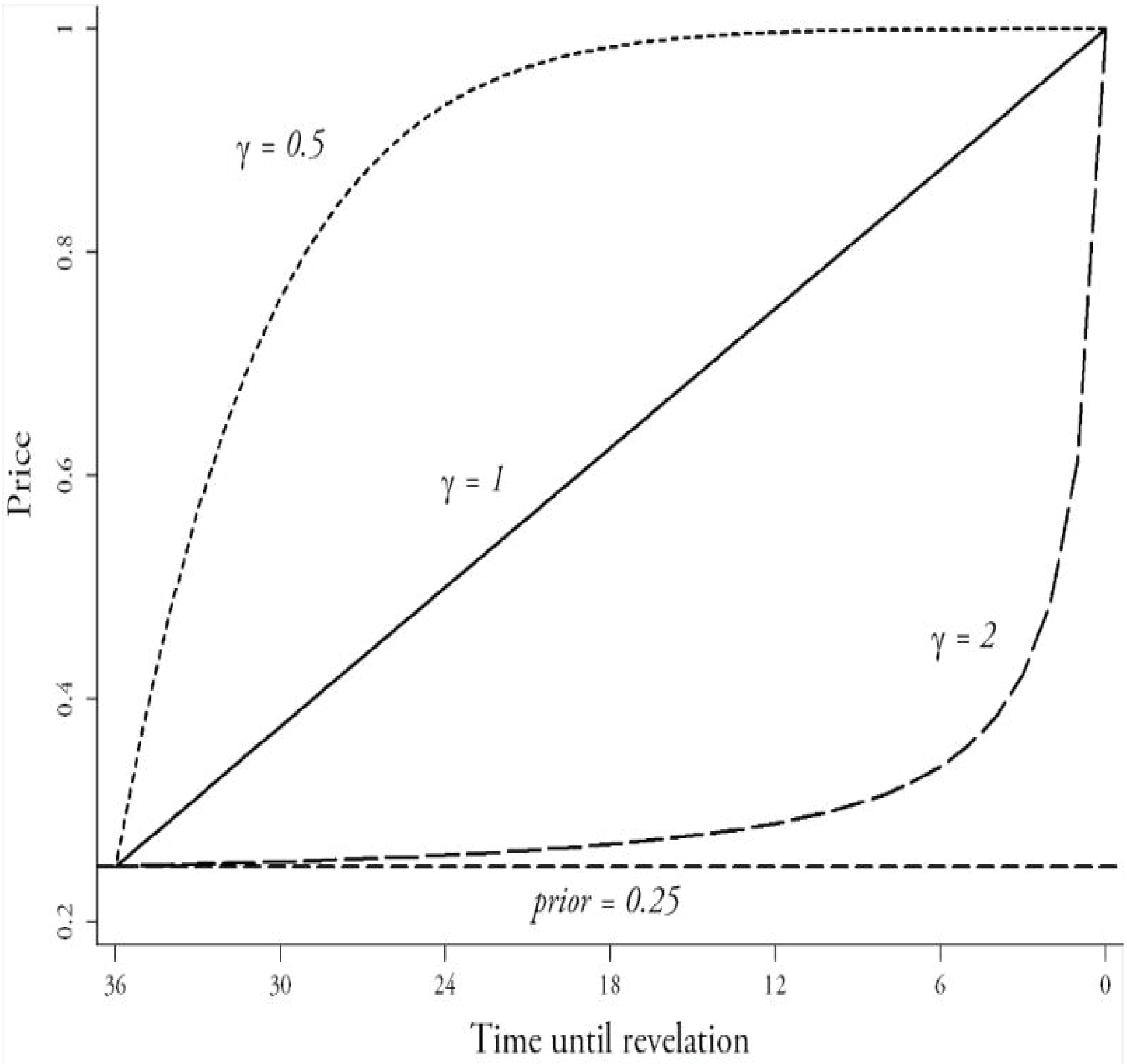
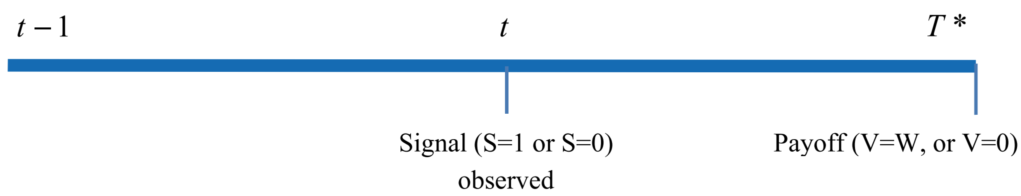


Figure B5. Timeline of Information Revelation and Price Determination in a Two-Period Setting



APPENDIX C
A REPRESENTATIVE SAMPLING OF "HETEROGENEOUS BELIEFS" PAPERS

Authors	Date	Conclusion
Harrison & Kreps	1978	Prices exceed the present value of their associated future dividend stream because they include a speculative, yet rational, resale component that stems from heterogeneous beliefs being aggregated into future prices; in fact, buying and holding a well-diversified portfolio actually leads to an expected negative net present value.
Varian	1985	Asset returns are increasing in the dispersion of subjective beliefs.
Harris and Raviv	1993	Differences of opinion among traders induce speculative trading that reproduces empirical regularities that have been documented concerning the relationship between volume and price.
Kandel & Pearson	1995	Allowing for heterogeneous beliefs explains observed levels of trading volume.
Morris	1996	Even small differences in prior beliefs lead to large speculative premiums during the learning process.
Kurz	1997	There is no equity premium puzzle. Rather, investors rationally demand to be compensated for endogeneously-propagated price uncertainty which is not permitted under RE.
Diether, et al.	2002	Even for otherwise similar stocks, those with higher dispersion in investor beliefs earn significantly lower future returns.
Massa & Simonov	2005	Both learning uncertainty and dispersion of beliefs are conditionally priced.
Jouini and Napp	2007	Belief heterogeneity is a priced source of risk that leads to globally higher risk premia and lower risk-free rates.
Cao & Yang	2009	Differences of opinion lead to increased trading volume in stock markets.
Anderson, et al.	2009	Belief heterogeneity helps explain apparent asset pricing puzzles because it is priced in traditional models.

Banerjee & Kremer	2010	Introducing learning into a production-based, long-run risk model increases the equilibrium equity premium; in the process, disagreement-induced speculation increases observed trading volume.
Xiong & Yan	2010	Heterogeneous expectations help explain several puzzling phenomena observed in bond markets.
Banerjee	2011	Only a low level of disagreement and learning is needed to match observed expected returns and return volatility.
Cogley, et al.	2012	In the presence of opportunities to speculate, learning that stems from agents having heterogeneous priors increases observed market prices of risk.

Complete bibliographic information is included in the References. Given the growing acceptance of models based on heterogeneous expectations, the extant literature has witnessed an explosion of papers devoted to an exploration of the asset pricing implications of opinion differences and learning. Hence, we had to be judicious in selecting the papers to include in this table. Our decision making process was as follows. We started by not only ruling out (some admittedly very promising) working papers, but also only considering papers that had been published in top journals. Within this subset, we ordered the papers by giving top priority to seminal papers, irrespective of their date and focus. Finally, we chose the remaining papers by favoring recent empirical works, all else equal.

APPENDIX D
QUOTES ILLUSTRATING CONSTRAINTS IMPOSED ON ELM ANALYSIS BY LACK OF PRIORS DATA

Bondarenko and Bossaerts (2000)

1537

In the absence of an explicit specification of priors and likelihood functions, we only test the central part of a Bayesian Equilibrium, namely investors' usage of Bayes' law to update beliefs.

We find that prices in the Iowa markets reflect rational learning. Evidence against rational expectations surfaces, however, indicating that investors may have started with biased priors.

1538

The negative correlation between the price level and the subsequent price change does indicate that market priors were biased. But we lack the necessary data to estimate the nature of this bias with sufficient precision.

1552

The evidence in Table A5 leads us to refute REE at high confidence levels. Because we concluded in the previous section that closing prices in the Iowa markets reflect rational learning, however, we cannot attribute this rejection to over-reaction (the explanation usually advanced for this phenomenon in the stock markets). It must be agents' beliefs. They are biased, in violation of one of the assumptions behind rational expectations.

[T]ogether with the negative relationship between price levels and subsequent returns, the deviations in the initial Microsoft High prices from fair value seem to indicate that Iowans started out with more extreme priors than can be justified *ex post*. Beliefs subsequently reverted back to some more acceptable level.

One would of course want more precise estimates of the nature of the belief biases over the particular period under study. Unfortunately, we observe only sixteen (one-month) histories of the evolution of the beliefs. This means that we implicitly only have sixteen sample points with which to compare the final outcome with the initial price (belief). Such a sample size is simply too small to make any confident statements about the direction of the bias in the market's priors.

It underscores the power of our methodology. However, we cannot go further and estimate precisely what the bias in initial beliefs was like.

1553

Since in-sample predictability violates rational expectations but agents appear to have correctly implemented Bayes' law, we conclude that their priors must have been biased. We do not have enough data, however, to estimate the precise nature of the biases in initial beliefs that participants in the Iowa markets appear to have had over the period under investigation.

1554

We did find that priors in the Iowa markets were biased. But these biases may have been period-specific. In other words, there is no guarantee that they would still be there in the future. Moreover, we did not have enough data to estimate their nature within acceptable limits.

Bossaerts (2004)

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MS's average stock return over the last 15 years has been high not necessarily because it was a high risk company, but probably mostly because the market initially thought it to be an average company, and subsequently had to revise its belief as evidence mounted of exceptional profit growth.

Sources are centered above all page numbers and quotes taken from the sources. Page numbers are in italics immediately above the quotes found on those pages. The quotes are fully-justified. They are separated by spaces when the quotes were not contiguous in the specified source.

APPENDIX E
IEM MOVIE MARKET NAMES AND MNEMONICS

Movie	Mnemonic
Lost in Space	lis
Mercury Rising	mr
I Still Know What You Did Last Summer	isk
Enemy of the State	eos
The Matrix	mat
10 Things I Hate about You	tti
Sleepy Hollow	sh
The World is Not Enough	wine
The 6th Day	six
How the Grinch Stole Christmas	grin
Monster's Inc.	minc
Harry Potter and the Sorcerer's Stone	hps
Die Another Day	die
The Cat in the Hat	cat
Tears of the Sun	sun
SpongeBob SquarePants	sbob
The Fountain	font
Happy Feet	hfet
300	thre
Beowulf	beow
Twilight	twlt

"Movie" refers to the name of the movie for which a particular IEM Movie Market was held. This official movie name is designated in the IEM Movie Markets' prospectus for that movie. "Mnemonic" is the abbreviation used by the IEM Movie Markets as a shortened reference to the associated movie. In particular, the contracts traded for a particular movie were named according to an alphanumeric combination consisting of the movie's mnemonic and the upper-bound-determining total 4-week U.S. box office receipts (in $millions) for a particular contract. We refer to markets by their mnemonic throughout the paper.

APPENDIX F
SAMPLE IEM MOVIE MARKET PROSPECTUS (HFET)

At noon, Central Time, Friday, November 3, 2006, the Iowa Electronic Market (IEM) will open trading in contracts based on box office receipts for the movie, "Happy Feet." This document describes those contracts and should be viewed as a supplement to the IEM Trader's Manual. Except as specified in this prospectus, trading rules for this market are the same as those specified in the Trader's Manual for the Iowa Electronic Market.

All contracts in this market (Movie_HFet) are winner-takes-all contracts. Liquidation values for these contracts will be determined by box office receipts for the movie "Happy Feet" during the period November 17, 2006 to and including December 14, 2006.

Contracts

The set of contracts initially traded in the market Movie_HFet are:

- HFet100L $1.00 if "Happy Feet" official box office receipts for the 11/17-12/14 period are lower than or equal to $100 million; zero otherwise
- HFet110L $1.00 if "Happy Feet" official box office receipts for the 11/17-12/14 period are greater than $100 million and lower than or equal to $110 million; zero otherwise
- HFet120L $1.00 if "Happy Feet" official box office receipts for the 11/17-12/14 period are greater than $110 million and lower than or equal to $120 million; zero otherwise
- HFet130L $1.00 if "Happy Feet" official box office receipts for the 11/17-12/14 period are greater than $120 million and lower than or equal to $130 million; zero otherwise
- HFet130H $1.00 if "Happy Feet" official box office receipts for the 11/17-12/14 period are greater than $130 million; zero otherwise

The IEM reserves the right to introduce new contracts as described in the "Contract Spin-offs" section below. Once a contract is listed, it will remain listed until liquidation.

Determination Of Liquidation Values

The liquidation values for these contracts will be determined by box office receipts for the period November 17, 2006 to December 14, 2006, inclusive, as published in Variety's Domestic Box Office Report under the heading "Cumulative Reported B.O." Note that the box office receipts for the period 12/15/2006-12/17/2006 are NOT included in the figure used for the liquidation values. In the event that the movie is not listed in this report, we will use AC Neilsen EDI, Inc. (www.entdata.com), the official source for the box office receipts reported in Variety, as our source.

The expected opening date for "Happy Feet" is November 17, 2006. Liquidation values will depend, however, on total box office receipts during the 11/17/2006-12/14/2006 interval regardless of the actual opening date. For example, if the movie fails to open by 12/14/2006, the lowest denominated contract (initially, HFet100L) will pay $1 and all others will pay $0.

Liquidation formulas can be viewed on the IEM trading screen by "clicking" on the name of the market, "Movie_HFet".

The judgment of the IEM Governors and Directors will be final in resolving questions of typographical or clerical errors and ambiguities.

Contract Spin-Offs

The Directors of the IEM reserve the right to introduce new contracts to the market as spin-offs of existing contracts. No holder of the pre-spinoff contracts will be adversely affected. Traders will receive the same number of each of the new contracts as they held in the original, and the sum of the liquidation values of the new contracts will equal the liquidation value which would be paid to the original in the absence of a spinoff.

If the trading price of a particular contract becomes unusually high, the Directors of the IEM may authorize a contract spin-off. When a contract spin-off occurs, the original contract will be replaced by two new contracts which divide the payoff range of the original contract into two intervals. For instance, if a contract spin-off is authorized for HFet120L, each trader holding an HFet120L contract would receive two new contracts in its place: HFetxxL (that would pay off $1 if box office receipts were higher than $110 million, but lower than or equal to $xx million), and a new HFet120L (that would pay off $1 if box office receipts were higher than $xx million, but lower than or equal to $120 million). Note that these contracts split the original payoff range (higher than $110 million, and lower than or equal to $120 million) into two new intervals. Since the value of the two new contracts can differ from that of the old contract, all outstanding bids and asks for the original contract will be canceled at the time of the spin-off.

All decisions to spin-off a contract will be announced at least two days in advance of the spin-off, and the new contract names and the timing of the spin-off will be included in the announcement. This announcement will appear as a News Bulletin on your IEM login screen.

Contract Bundles

Fixed-price bundles consisting of one share of each of the contracts in this market can be purchased from or sold to the IEM system at any time. The price of each bundle is $1.00. Because exactly one of the listed outcomes will occur, the total payoff from holding a bundle consisting of one of each contract until the market closes is $1.00.

To buy or sell fixed-price bundles from the IEM exchange, use the "Market Orders" option from the trading Console. Select the option "Movie_HFet (buy at fixed price)" from the Market Orders list buy bundles. Select the "Movie_HFet (sell at fixed price)" option to sell bundles.

Bundles consisting of one share of each of the contracts in this market may also be purchased and sold at current aggregate market prices rather than the fixed price of $1.00. To buy a market bundle at current ASK prices, use the "Market Order" option as above but select the option "Movie_HFet (buy at market prices)". To sell a bundle at current BID prices, select the option "Movie_HFet (sell at market prices)".

Bundle purchases will be charged to your cash account and bundle sales will be credited to your cash account.

Market Closing

The market will close at noon on Friday, December 15, 2006. As soon after that time as the official results are known, liquidation values will be declared and funds will be credited to the cash accounts of the market participants.

Market Access

Only IEM traders enrolled in the daytime MBA 6N:211 and 6N:240 courses will be given access rights to the Happy Feet Movie Box Office Market. Access to the market is achieved via the "Market Selection" pull-down menu on either the Login-Welcome screen or at the bottom of the Trading Screen.

Funds in the IEM Movie Box Office Markets associated with "Happy Feet" trading accounts are not fungible across markets until after the contracts associated with both markets are liquidated. Additional investments up to the maximum of $500 can be made at any time.

Requests to withdraw funds may be submitted at any time by completing the IEM's Online Withdrawal Request form or by completing and mailing the paper version of the request form. Additional information about requesting withdrawals is available at tippie.uiowa.edu/iem/accounts/withdrawals.html.

APPENDIX G
SAMPLE FORECAST SURVEY

6N:211 IEM Movie Market Survey Name:_______________ SS#___________

Please fill out the following questions about your IEM Movie Markets Forecasting assignment.

1. For the movie "How the Grinch Stole Christmas," estimate the probability that the four-week box office receipts will be:

a. < \$70 million _______________ *Note: the total probability for a-e should = 100%*
b. ≥ \$70 million and < \$ 90 million _______________
c. ≥ \$90 million and <\$110 million _______________
d. ≥ \$110 million and < \$130 million _______________
e. >\$130 million _______________

2. How confident are you that your forecast for "How the Grinch Stole Christmas" is accurate? (circle one)

a. Very confident
b. Somewhat confident
c. Slightly confident
d. Not at all confident

3. Compared to the forecasts of the other students in the class, is your forecast for "How the Grinch Stole Christmas" (circle one)

a. Much more accurate
b. Somewhat more accurate
c. About the same
d. Somewhat less accurate
e. Much less accurate

4. For the movie "The 6th Day," estimate the probability that the four-week box office receipts will be:

a. < \$70 million _______________ *Note: the total probability for a-e should = 100%*
b. ≥ \$50 million and <\$70 million _______________
c. ≥ \$70 million and <\$90 millon _______________
d. ≥ \$90 million and <\$110 million _______________
e. >\$110 million _______________

5. How confident are you that your forecast for "The 6th Day" is accurate?

a. Very confident
b. Somewhat confident
c. Slightly confident
d. Not at all confident

6. Compared to the forecasts of the other students in the class, is your forecast for "The 6th Day" (circle one)

a. Much more accurate
b. Somewhat more accurate
c. About the same
d. Somewhat less accurate
e. Much less accurate

Please continue on the next page

7. Compared to the average student in the class, how much money do you expect to make in the movie markets? (circle one)

a. Much less than the average
b. Somewhat less than the average
c. About the same as the average
d. Somewhat more than the average
e. Much more than the average

8. Compared to the average student in the class, how much of the information available on the internet did you use for your forecasts? (circle one)

a. Much more information
b. Somewhat more information
c. About the same amount of information
d. Somewhat less information
e. Much less information

9. Compared to the other student in the class, I spent…(circle one)

a. Much more time on this assignment
b. Somewhat more time on this assignment
c. About the same amount of time
d. Somewhat less time on this assignment
e. Much less time on this assignment

10. Compared to the average student in this class, I expect to…(circle one)

a. Trade much more in the markets
b. Trade more in the markets
c. Trade about the same amount
d. Trade less in the market
e. Trade much less in the markets

11. I have an effective trading strategy for making money in the IEM Movie Markets. (circle one)

a. Definitely agree
b. Somewhat agree
c. Neither agree nor disagree
d. Somewhat disagree
e. Strongly disagree

12. How interested are you in seeing "How the Grinch Stole Christmas"?

a. Strongly interested
b. Somewhat interested
c. Slightly interested
d. Not at all interested

13. How interested are you in seeing "The 6th Day"?

a. Strongly interested
b. Somewhat interested
c. Slightly interested
d. Not at all interested

Thank you!

APPENDIX H
PROOF THAT THE STOCHASTIC PROCESS GOVERNING THE EVOLUTION OF BINARY OPTION CONTRACT PRICES IS A MARTINGALE

Claim:

$$p_t = E_t\left[p_{t-1}\right].$$

$$p_{t_{i-1}} = E_{t_{i-1}}\left[p_{t_i}\right], \text{ for the time index, } \tau_i = i\tau, \text{ where } i = \{0,1,\ldots,N\}, \text{ and } \tau_0 = 0$$

$$= \left[p_{t_i} + \frac{1-p_{t_i}}{t_i^\gamma}\right]\left[p_{t_i}\right] + \left[p_{t_i} - \frac{p_{t_i}}{t_i^\gamma}\right]\left[1-p_{t_i}\right]$$

$$= \frac{t_i^\gamma p_{t_i} + p_{t_i} - p_{t_i}{}^2 + t_i^\gamma p_{t_i} - p_{t_i} - t_i^\gamma p_{t_i}{}^2 + p_{t_i}{}^2}{t_i^\gamma}$$

$$= \frac{t_i^\gamma p_{t_i}}{t_i^\gamma}$$

$$= p_{t_i}$$

Q.E.D.

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