Real Effects of Accounting Uniformity: Implications of Higher-Order Beliefs[1]

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Abstract

We theoretically and experimentally investigate the effect of uniformity in accounting measurement on value enhancing coordination in the presence of strategic uncertainty. We use a setting where two partners have differential information due to non-uniform accounting system about the gains form coordinated investment, and derive equilibrium predictions of when coordination is expected to occur (i) when each partner's behavior relies only upon on their own beliefs of the fundamental uncertainty, and (ii) when higher-order iterative reasoning of beliefs prevents coordination and wealth creation. Our experimental design allows us to control for various behavioral phenomena and examine participants' decisions across different accounting regimes as to isolate the coordination effect of strategic uncertainty resulting from non-uniform accounting measurement. Our results suggest that participants exercise higher order belief thinking, albeit only to a limited degree, when both fundamental and strategic uncertainty exists, that can potentially cause breakdown of welfare enhancing coordination. Therefore, not only the information, but also the shared understanding of the information, can affect wealth creation. These results can offer insight into when more uniform measurement rules are desirable.

Key words: accounting uniformity, coordination, higher-order beliefs
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1. Introduction

In this study we theoretically and experimentally examine the effect accounting measurement of the underlying economic fundamentals has upon welfare enhancing coordination. In particular, we examine if uniformity of accounting measurement affects interacting parties' coordinating behavior via strategic uncertainty. We ask that in a coordination setting, when agents exercise higher-order iterative thinking, even only to a limited degree, does the uniformity of rules governing accounting measurements have real effects, or alternatively, can non-uniformity in accounting measurement reduce wealth creation beyond stock valuation and trade or contractual tensions?

The debate whether uniformity in accounting rules is desirable, and to what extent it should be implemented, has been a long standing issue.[3] Traditionally the Financial Accounting Standards Board (FASB) has been leaning toward eliminating or reducing flexibility in accounting practices (FASB 1979), but this does not come without strong oppositions (Foster III and Vickrey 1978). Proponents argue that non-uniformity in accounting rules increases comparability of firms and, as a result, improves capital allocation; it reduces the scope of management opportunity to manipulate information communication (Schipper 1989, Graham et al. 2005) that causes damaged investor confidence and dead weight loss (Bloomfield 1996; Stein 1989); it also provides auditors protection through enabling them to operate in a tightly structured environment which minimizes judgment and thus the risk of legal liability (Lev 1976). Opponents' voice is equally strong, if not stronger. They argue that uniformity in accounting rules hinders private information communication by forcing homogeneous treatment on heterogenous transactions (Hann et al. 2007, Dye and Sridhar 2008) and prevents welfare improving regulatory competition (Bertomeu and Cheynel 2013, Sunder 2013). Recently such a debate has gone beyond the optimal structure of an accounting standard (e.g., Dye and Verrecchia 1995) to the social desirability of one single uniform accounting standard such as the International Financial Reporting Standard (Ray 2012). Flynn's (1965) summarization of the status of this debate, "[T]he road has been long, and the end is not in sight", is still applicable even a half century later.

[3] Flynn (1965) describes the progress as "[T]he roots of the problem go back a good many years-perhaps as far back as the history of accounting itself. We may … in the early 1930s".

The objective of this paper is to add to this debate a new dimension that has not been explored. Once an economic transaction or substance has been identified, accounting takes two major steps to reflect this underlying fundamental in the final accounting reports – measurement and communication. The extant effort in the debate of uniformity of accounting rules has been generally focused on the disclosure of private information by the management to the outsiders who make decisions based upon the information they receive from the management (e.g., Hann et al. 2007, Dye and Verrecchia 1995). Communication of private information is undoubtedly subject to management reporting incentives. We depart from this literature by abstracting away any reporting incentives, but rather focusing on the more primitive step – the measurement of the underlying economic transaction/substance. We demonstrate that even absent of any principal-agent conflicts, uniformity in accounting rules has real implications for firms' behavior.

We envision a setting where two parties need to coordinate their investment behavior in order to realize a potential gain of a project, but they are endowed with differential information about the return of the project, and they both know that there is disagreement in their posterior beliefs (Harsanyi 1968, Aumann 1976). Two types of uncertainties with regard to the project return arise in this setting: 1) fundamental uncertainty, i.e., the two parties have different beliefs about the return of the project in question, and 2) strategic uncertainty, i.e., each party is uncertain about the beliefs of the other party. The strategic interplay between the two types of uncertainty gives rise to Keynes' analogue of capital asset pricing to the "beauty contests" (Keynes 1936) that highlights the importance of higher order beliefs in capital markets.

Higher-order beliefs thinking is a theoretical modeling of rational agents who not only consider the fundamental economic risk, but the beliefs of others, beliefs of beliefs of others, and so on. The analytical body of work examining the iterative nature of beliefs posits that small disagreement in the beliefs about the fundamental uncertainty can have pronounced economic consequences. At an extreme, even with nearly common information agents respond to others as a possibly detrimental event occurred, even though both agents know the event could not have possibly occurred. Why? While the agent knows that others also know it could not have occurred, she does not necessarily know that the others know that she knows it has not occurred. Work by economists Stephen Morris, Hyun Shin, and others (Rubinstein 1989, Shin 1996, Allen, Morris and Shin 2006, Morris and Shin 2012) precisely models how this happens. This line of thinking has found applications in accounting and finance in an attempt to explain price drift (Banerjee, Kaniel and Kremer 2009) and market efficiency of public accounting disclosure (Gao 2007).

Higher-order beliefs thinking in coordination scenarios may have important implications on the design of accounting standards. A primary objective of accounting is to facilitate flow of value relevant information among interested parties to improve decision-making. Such a function of accounting demands common understanding. As such, accounting needs to have the ability to coordinate behavior within a framework of shared understanding of information contained in accounting reports. On one hand, imposing uniformity in accounting measurement may suppress substantive variations among similar economic transactions conducted in various decision environments. But on the other hand, non-uniform accounting measurement may generate dispersion in beliefs that theoretically yields inefficiency according to higher-order reasoning.

We utilize a setting where the dispersion in agents' beliefs about the return of an risky investment in question comes solely from the differential measurement rules resultant from the discretion granted by GAAP. We build a parsimonious model to derive predictions in scenarios where non-uniform accounting measurement rules invoke agents' higher-order beliefs thinking, and test experimentally the model using a design that allows for non-modeled differences in preferences, such that the only differences between various baseline measures are due to beliefs of others. In this setting joint investment by the two parties is expected to occur if both parties act upon only on their own beliefs of the fundamental uncertainty about the return of the project. Each party is predicted to act only on its own beliefs of the fundamental uncertainty when (i) accounting measurements use uniform rules or (ii) no party engages in higher-order reasoning. However, if coordinating parties engage in some degree of higher-order iterative reasoning of the beliefs of their partners, and their partners' beliefs of their beliefs, and so on, coordination will decrease. Coordinating parties are predicted to use higher-order reasoning only when accounting measurements are non-uniform between the two parties. We then experimentally examine when both fundamental and strategic uncertainty exists whether agents' coordination is reduced as a result of their practice of the aforementioned iterative reasoning arising from non-uniform accounting measurements.

We find evidence that under our parameter values, wealth creating coordination is drastically reduced when the two parties' accounting measurements are different after controlling for other factors that are known or believed to affect coordination. The result is consistent with the notion that the disagreement between agents' beliefs about the return of the risky investment (the fundamental uncertainty), together with their beliefs about the beliefs of their partners (strategic uncertainty), makes non-uniformity in accounting measurements value destroying. Our result also suggests that beliefs of others do economically matter in the economic decision making, and that the observed behavior is consistent with the iterative process underlying analytical predictions of higher order belief models. However, the observed iterative process falls short of equilibrium prediction, consistent with prior research (Nagel 1995, Costa-Gomes et al. 2001).

Our paper contributes to the ongoing debate over the desirability of uniformity in accounting standards setting. Horwitz and Kolodny (1980) evaluate the economic effects of the mandated rules of the FASB requiring a single, uniform method of accounting for research and development (R&D) expenditures. They document that the expense-only rule caused a significant reduction in the level of R&D investments for firms that had previously used the deferral method. Hann, Lu, and Subramanyam (2007) examine the effects of discretion allowed under GAAP on the value relevance of the pension obligation and conclude that allowing flexibility in the choice of pension assumptions on average improves information communication through the projected benefit obligation. On the theory side, Dye and Verrecchia (1995) study a setting where firm's current period activities create expenses that are not realized until future periods and there is a question as to how much of these future expenses should be recognized currently, in the presence of both an internal agency problem (problem between a firm's shareholders and their manager) and an external agency problem (problem between current and prospective shareholders). They show that discretionary GAAP is always preferred over uniform GAAP if the internal agency problem is the only concern, however, when both internal and external agency problems are present concurrently, discretionary GAAP can be inferior to uniform GAAP. Dye and Sridhar (2008) model uniformity versus flexibility in terms of whether the biases in the mapping form the underlying transactions to the accounting numbers are common across firms or firm specific. A central result is that firms prefer uniformity over flexibility when the measured transactions are more homogenous or when there is substantial variation in how transactions are measured for reasons unrelated to the economic value of the transactions.

The extant effort on uniformity focuses on the tradeoff between the improved information communication and opportunistic manipulation by the management[4]. We examine this issue in a setting where there is there is no room or need for any opportunistic manipulation of financial information. We abstract away from any internal and external agency problems, but focus exclusively on how higher order beliefs of participating agents affect the social welfare when non-uniform accounting measurements create disagreement between the transactional parties in their beliefs regarding the return of the underlying investment. Thus we identify a previously unexplored reason that uniformity in accounting standards might be desirable. We provide empirical evidence that not only the information, but also the shared understanding, matter in promoting coordination efficiency. We hope that by investigating the implication of participants' iterative thinking on value enhancing coordination, we may shed light on such an important debate.

Our paper also contributes to our understanding of whether agents apply the iterative thinking in economic decision making when both fundamental and strategic uncertainties exist. Despite the intuitive and theoretical appeal of the analytical models on higher order belief thinking, the predictive power is mixed. The resulting logic embedded in higher-order beliefs thinking requires agents to do rounds of iterative reasoning and deletion of dominated strategies. Studies of iterative reasoning strongly suggest people are only partially apt to calculate many rounds of reasoning (Nagel, 1995; Costa-Gomes, Crawford and Broseta, 2001, Ho, Camerer, C. and Weigelt 1998; Stahl and Wilson 1994). At the same time experimental studies of coordination games suggest higher-order beliefs predictions are directionally borne out (Anctil et al., 2004; Qu 2013). We provide some empirical evidence on the effects of agents' iterative reasoning of beliefs on the market's ability of generating welfare enhancing coordination. The development in formally modeling the notion of higher order beliefs offers us an opportunity to identify a simple coordination scenario to experimentally examine this issue.

[4] Dye and Verrecchia (1995) point out that "whether expanding discretion in accounting choice is desirable appears to depend on whether the prospects for improved communication of the firm's financial condition are more than offset by the effects of managerial opportunism."

Our constructed game allows us to separate fundamental and strategic uncertainty. The extensive theoretical literature on voluntary and mandatory disclosure offers great insight into how fundamental uncertainty is considered in capital markets (e.g., Verrecchia 2001, Dye 2001, and Kanodia 2007 provide a series of comprehensive review of papers in this line of research that use various modeling approaches). Empirical accounting research provides prima fascia evidence that beliefs do matter. However, these papers generally leave the strategic uncertainty out of picture. Our approach helps us to clearly attribute a reduction in coordination to strategic uncertainty.[5]

The rest of the paper proceeds as follows. In Section 2, we present a parsimonious model to provide conditions underlying higher-order beliefs thinking and develop our hypotheses. We next discuss the experimental design and procedures. We discuss the experimental results in Section 4. Section 5 concludes.

2. A Theoretical Framework

Two risk-neutral entrepreneurs are interested in a joint venture. The return on their investment in the joint venture depends upon the realization of the state of Nature, which is ex ante equally likely to be 'peach' or 'lemon'. If the realized state is 'lemon', one entrepreneur (labeled as Agent L hereafter) enjoys a high rate of return (labeled as payoff G), while the other entrepreneur (labeled as Agent P hereafter) has a low rate of return (or L) if both entrepreneurs invest and the joint venture is formed. Alternatively, in the 'peach' state Agent P enjoys a payoff G while Agent L has a payoff L. If no one invests or only one invests, the joint venture will not be established.

Motivated by Morris and Shin (2012), we examine a setting with adverse selection that allows us to discuss the decisions faced by Agents P and L before examining a richer setting where there is possibly lack of common information of payoffs when accounting measurement rules are not uniform. This possible divergence allows us to introduce a role for higher-order

[5] The work of Bloomfield (1997), Zimbelman and Waller (1999), and Anctil et al. (2004) studies the implications of participants' higher-order thinking in strategic audit and loan coordination settings, and provides experimental evidence that is consistent with participants' exercising higher-order thinking when they face both fundamental and strategic uncertainty. However, the effects of fundamental and strategic uncertainty are intermingled. Our setting allows us to exclusively attribute the observed reduced coordination and welfare to the strategic uncertainty. Further, these prior studies do not control for alternative explanations, such as risk and/or complexity aversion (Bossaerts et al. 2010). By varying our experimental treatments and comparing the results across these treatments, we gain a better appreciation of the distinct roles that these different forces play in coordination.

beliefs. We start with a single hypothetical payoff table to isolate the basic tensions due to private information before introducing multiple payoff tables, and thereafter, potentially different information received by the two entrepreneurs.

2.1 Setting with a Single Payoff Table

Agent P's net payoff is G for the peach outcome and L for the lemon outcome, where $G > L$. Symmetrically, Agent L's net payoff is L and G for the peach and lemon outcomes, respectively. These payoffs are common knowledge. Both agents may have private information regarding the future and it is common knowledge that each agent is equally likely to be informed or uninformed of the lemon or peach outcome. As such both, neither, or only one agent might be privy to the future payoffs. Both agents must jointly and simultaneously agree to invest and forgo opportunity with a payoff of E (where we assume $G > E > L$ and $E > 0$), or joint venture is not established. We also assume $G + L > 2E$, so that aggregate gains to joint investment exceed foregone opportunity, and as such, coordination is socially efficient.

For exposition, the pronoun 'she' refers to the decision maker, and 'he' refers to the paired coordinating partner. Some observations regarding the simultaneous-move game:

1) Assuming strictly selfish preferences, if one sees her payoff is G, she will invest. Symmetrically, if the payoff is L she will not invest.
2) Consequently, any scenario where there is joint investment is one where at least one agent is uninformed of the outcome.

Imagine one agent (she) does not know the outcome, so from her perspective there are two possibilities: either the other agent (he) is also uninformed or is informed. Additionally, she also knows that when she invests, if he is informed and learns his outcome is L, he will not invest, so her payoff will be E; If he is informed and learns his outcome is G, he will invest and her outcome is L. So she, when uninformed, might invest if her expected payoffs from investment are greater than the foregone opportunity, given by eq. (1).

$$\underbrace{\frac{1}{2}}_{\text{other informed}} \left[\underbrace{\frac{1}{2}L}_{\text{other agrees}} + \underbrace{\frac{1}{2}E}_{\text{other rejects}} \right] + \underbrace{\frac{1}{2}}_{\text{other ignorant}} \left[\underbrace{\frac{G+L}{2}}_{\text{average result}} \right] \geq E$$

$$\Rightarrow L \geq \frac{3E - G}{2} \tag{1}$$

If eq. (1) is true, then both parties invest when uninformed if, and only if, they believe the other agent does the same. However, if eq. (1) is false, then neither will invest when uninformed, and the equilibrium is one of no joint venture. We summarize these modeling claims below.

Claim 1

(a) If an agent is informed, she invests when she knows the outcome is favorable and does not when she knows the outcome is unfavorable;

(b) If an agent is uninformed and eq. (1) is false, then there is a unique equilibrium of no investment;

(c) If an agent is uninformed and eq. (1) is true, there is a non-unique equilibrium where uninformed parties invest;[6]

(d) The maximum ex-ante probability of joint investment is one-half when eq. (1) is true and zero otherwise.

Proof: In the appendix.

2.2 A Setting with Multiple Payoff Tables

Having introduced the underlying tensions due to adverse selection, we examine a setting with three payoff tables denoted as A, B, or C, each with two outcomes of peach or lemon. Assume each payoff table is equally likely, and both the favorable outcome $G = 10$ and the opportunity costs $E = 5$ are identical in each payoff table.[7] However, the unfavorable outcome differs, $L \in \{L_A = 3.2, L_B = 3,\ L_C = 2\}$. One could think of payoff table A as the least risky to conduct investment when uninformed and payoff table C as the most risky. Notice that while joint investment increases welfare for all payoff tables (i.e., $10 + L_i > 10 = 2 * E$ for $i = A, B,$ or C), eq.(1) only holds true for A and B, but not for C.

Imagine an agent's accounting system perfectly reveals the future payoff table, that is, it provides a definite lower bound on the potential loss, then by Claim 1, joint investment is possible only when the payoff table is A or B. Fearing loss, an uninformed agent would not invest when the payoff table is C as per Claim 1 (b). Note that despite perfect information

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[6] There always exists an equilibrium where no joint investment occurs when (i) one agent always offers to invest but the other agent never does, or (ii) neither agent ever offers to invest. For risk neutral uninformed agents, the no investment equilibrium is at least weakly dominated by the joint investment equilibrium.

[7] The relaxation of these assumptions does not change the nature of the analysis nor yield any additional insights.

regarding the payoff tables, there is inefficiency as coordination can only occur when (i) the payoff table is not C, and (ii) at least one of the agents is uninformed. As such, coordination can happen at most one-third of the time.[8]

2.3 Accounting Measurements

Now we introduce information structures that may give rise to higher-order beliefs. We assume that before electing to invest, each agent receives a private signal of the future payoff table from her accounting system. The signal provides an estimate of the economic fundamentals. The signal is in the form of a partition where the true payoff table is one of the elements in the partition. We assume the partition structures are common knowledge to all agents. If the signal has one element, then the agent knows the payoff table with certainty. If the signal has two elements, then the agent knows the payoff table is equally likely to be either element of her signal. We focus on structures that map the three payoff tables into two-partitions. The different mappings operationalize different accounting measurement rules where all the information contained within the accounting system is summarized into a bifurcated estimate, reporting either a high or a low value. The first structure is S1 = *{{A}, {B, C}}* and the second is S2 = *{{A, B}, {C}}*.

Imagine both agents use S1, an aggressive accounting system that focuses measurement rules upon whether the future payoff table is the least risky or not. If the payoff table was B, both agents would receive the signal *{B,C}*. Furthermore, she would know he received the same signal, and that he knew that she received the same signal.

Similarly, both agents may use S2, a conservative accounting system that focuses measurement rules upon whether the payoff table is the most risky, or not. In this case, if the payoff table was B, then both agents receive the signal *{A,B}*. As above, she knows that he knows that she knows the signal is *{A,B}*.

Alternatively, the accounting measurements rules may not be uniform. The parties use different measurement rules, and furthermore, each party knows the other uses a different structure (Harsanyi 1968, Aumann 1976). Imagine Agent P uses S1, while Agent L uses S2. If that payoff table is B, then Agent P receives s_1 = *{B, C}* and Agent L receives s_2 = {*A*, *B}*. In

[8] Under Claim 1, the maximum ex-ante probability of joint investment is 1/2 for payoff tables A and B, and is zero for C. Each payoff table has equal chance of occurring; hence the overall probability is 1/3.

contrast to the aforementioned uniform accounting measurement systems, the signal s_1 or s_2 received by each agent is private. Agent P receiving *{B, C}* knows Agent L might have received the signal *{A,B}* or *{C}*. There is no common understanding of what the other agent believes she knows, as there is no common observability.

When an agent is informed of the outcome (i.e. lemon or peach), it is straightforward to show that Claim 1(a) applies for all three possible payoff tables. Here we focus on the more interesting case where the agent is uninformed of the outcome and unsure whether her partner is informed or uninformed. We demonstrate below that using the experimental parameters, coordinated investment is possible when the information partition is the same for both agents, but when the information partitions are different as a result of application of different accounting measurement rules by the two agents, coordination completely collapses due to higher-order beliefs.

Claim 2

If Agent P's information set is {{A},{B, C}} and Agent L's information set is {{A, B},{C}}, then higher-order beliefs dictates there exists a unique equilibrium where uninformed agents choose not to invest regardless of the signals observed. Because uninformed agents never invest, informed agents are indifferent to invest when the outcome is favorable, but will not invest when the outcome is unfavorable. As a result, there is never coordinated investment and social welfare is zero. When both agents' information set is {{A, B},{C}}, there exists a non-unique equilibrium where uninformed agents invest for signal {A,B} but not for {C}. When both agents' information set is {{A},{B, C}}, there exists a non-unique equilibrium where uninformed agents invest for all signals received.

Proof: In the Appendix.

3. Method

3.1 The Experimental Task

We employ a 1 ×3 design, consisting of within-subject and between-subjects measures. For the within-subject portion, we manipulate whether knowledge of the payoff table is perfect or contained in a partition. For the between-subject portion, we manipulate whether the partitions are uniform across three treatments.

Participants make a single decision in every round to invest or not. Participants interact in two-person groups that are randomly and anonymously assigned each round. Participates are randomly assigned to a single experimental treatment consisting of three parts:

1. In Part I participants know the payoff table (i.e., A, B, or C). However, participants *never* know the outcome when deciding to invest (i.e., lemon or peach). As such, there is no adverse selection. Part I lasts 5 rounds and is the same for each treatment.
2. In Part II participants again know the payoff table, but also have a 1/2 chance of knowing the outcome before deciding to invest. This Part lasts 10 rounds and is the same for each treatment.
3. In Part III participants receive imperfect information about the payoff table via a partition and again have a 1/2 chance of knowing the outcome before deciding to invest. This part lasts 20 rounds and differs over treatments.

3.2 Treatments

We manipulate the uniformity of the accounting measurement used in Part III over three treatments. In the first and second treatments, both parties have an identical partition that isolates payoff table A from B and C (UNIFORM A), or isolates payoff table C from A and B (UNIFORM C). In these two treatments, there is common information between the two agents, and thus while fundamental uncertainty exists, theoretically there is no role for the higher-order beliefs to emerge. In the last treatment, the NON-UNIFORM treatment, however, Agent P's accounting system isolates payoff table A, but Agent L's accounting system isolates payoff table C. The parameters and partitions are shown in Table 1.

By comparing choices in Part III over treatments, we can measure how different accounting systems alter behavior with equally experienced agents, measure the resulting wealth created, and attribute the observed results to alternative hypotheses.[9]

[Insert Table 1 about here]

3.3 Procedure

The experiment was conducted at a North American university. 96 participants were recruited from a standard participant pool consisting primarily of undergraduate students and randomly

[9] Comparing choices in Part III keeps constant any effect of learning on participants' behavior across treatments.

assigned into treatments. Participants interacted with each other anonymously over a local computer network. The experiment was programmed and conducted using z-Tree (Fischbacher, 2007). The computers were placed within individual cubicles in such a way that all participants could only view their own computer screen.

Each session consists of 24 participants and lasts approximately sixty-five minutes. For Part I, an experimenter reads the instructions aloud as each participant follows along with their own copy of the instructions (example available in Attachment 1). The instructions explain the experimental procedures and payoffs used. During the instructions, participants are given five minutes to write down their answers to several questions to ensure that they understand the instructions and tasks. Participants' answers remain confidential. After participants complete the quiz, the correct quiz solutions are projected overhead while the experimenter explains the solutions (projections available in Attachment 2). The experimenter privately answers any questions regarding the experimental procedures. Each participant is assigned a role of Agent P or Agent L and remained in that role for the entire experiment. The participants are randomly regrouped using the stranger's protocol for each round (where they will not interact with another participant more than once).

The sequence of events is repeated for Part II and again for Part III. After completing all parts participants fill out an open-ended questionnaire asking them to explain how they came to their decisions. Each participant is paid a US $7 fixed fee and the payoffs after signing a receipt. Participants are paid for one randomly selected round from each part.

While in the manuscript we use the terms 'Agent P', 'Agent L', 'lemon', 'peach', etc.., we strive to use neutral terms in the experimental materials as to minimize experimenter demands or unintended normative behavior. All treatments use instructions that differed only in the exposition of Part III. The same experimenter conducts all treatments.

3.4 Hypothesis of Participant Behavior

While simple, the use of differential information partitions in the NON-UNIFORM treatment provides a setting where coordination is not theoretically possible and any benefits of joint investment are foregone. As illustrated in the proof of Claim 2, a thought exercise converges to equilibrium after three iterations from a base-level strategy. We summarize the equilibrium predictions on whether coordinated investment should occur for all levels of iterative thinking in the NON-UNIFORM treatment in Table 2. Since there is not common knowledge in regards to the payoff table, each agent conjectures the other's strategy conditional upon her information, and determines a best response. Because there is common observability of information in the UNIFORM A and UNIFORM B treatments, a single iteration leads to equilibrium.

[Insert Table 2 about here]

Higher-order thinking theorizes participants form a mental model that includes the perspective of others in an iterative fashion. Observing within-subject investment patterns in the NON-UNIFORM treatment allows us to infer whether, and to what extent, agents exercise higher-order thinking when deciding whether they want to undertake investment or not.

At the same time, experimental research suggests that participants believe others are less strategic than themselves and are skeptical of others' actions. This behavior is consistent with a common empirical regularity routinely documented by behavioral economists: participants tend to under-estimate the degree to which others are strategic (Stahl and Wilson, 1995; Ho, Camerer and Weigelt ,1998; Costa-Gomes, Crawford and Broseta, 2001). This would suggest that in the face of strategic uncertainty, a modest level of iterative thinking might be exercised.

Alternatively other research suggests participants in experiments insufficiently, or even fail to, consider the perspectives of other when deriving their own strategy (Moore and Kim, 2003; Hales, 2009). If this was the case, even if the non-uniform accounting measurement produces strategic uncertainty, the prediction of null investment is not realized when only a base level of iterative thinking is exercised.

Hypothesis 1 In the NON-UNIFORM treatment, comparing the behavior of uninformed participants in Part III to that in Part II:[10]

(a) If only the base level of iterative thinking is exercised, there will be no change in coordinated investments;

(b) If only moderate level of iterative thinking is exercised (one or two), coordinated investments should decrease for uninformed Agents P receiving *{B,C}* but for *{A}*, and for Agents L receiving *{A,B};*

[10] Recall there is two types of information – information about the outcome (e.g., lemon or peach) and information about the payoff tables (e.g., A, B, or C). By "uninformed", we mean the trader does not have information about the outcome, but she may have information about the payoff tables.

(c) If highest level of iterative thinking (three or more in this setting) is exercised, coordinated investment will decrease for all uninformed agents.

Our design allows us to test whether alternative theories on why coordination may decrease in the NON-UNIFORM treatment between Part II and Part III other than from higher-order thinking. First, a decrease in coordinated investment when seeing information partitions with two elements (i.e., *{A, B}*) may be due solely to complexity aversion (Sonsino and Mandelbaum, 2001; Halevy and Feltkamp 2005; Halevy, 2007), where participants prefer probabilistically equivalent simpler lotteries to compound gambles lotteries. Akin to risk aversion, complexity-averse participants would pay a premium for a simpler gamble, which would lead to decreased coordination between a benchmark perfect information partition and the partitions used in our treatments. Second, investing when uninformed is one of two possible equilibrium predictions when the payoff table is A or B. Over time participants may learn that others are not willing to invest when uninformed, and in response alter their own strategy, resulting in less coordinated investment.

Comparison of the NON-UNIFORM treatment to the UNIFORM A and UNIFORM B treatments allows us to falsify these alternative hypotheses. Agents L in UNIFORM C and NON-UNIFORM treatments, as well as Agents P in UNIFORM A and NON-UNIFORM treatments have the same information partition. The only difference is whether they face partners with same or different information partition, which provides room for higher-order thinking. If complexity aversion is the only contributor to the changes in trading activities, we should not expect to observe significant changes in coordinated investments for Agents L in UNIFORM C and NON-UNIFORM, and Agents P in UNIFORM A and NON-UNIFORM. The same would be true if participants discover that others are not willing to invest when uninformed, and are moving to the non-unique no-investment equilibrium prediction. So the changes, if any, can only be contributed to higher-order beliefs.

If participants' behavior is predicted using iterative thinking, we can rank order coordinated investments across-subjects over treatment. As shown in Table 2, the UNIFORM A treatment will generate the most coordination, and the NON-UNIFORM treatment the least. However, if participants' behavior is predicted solely due to complexity aversion, then coordination will be the same between treatments given the same information partition.

We state these predictions in the following hypothesis.

Hypothesis 2

(a) If participants' behavior is the result of pure complexity aversion or learning that others are not willing to invest when uninformed, then coordinated investment when receiving signals *{A, B}* or *{B, C}* should be equal between treatments.

(b) Alternately, if participants exercise iterative thinking when deciding whether they want to undertake investment or not then coordinated investment when receiving signals *{A, B}* or *{B, C}* should be smaller in the NON-UNIFORM treatment than in the UNIFORM A and UNIFORM C treatments.

(c) If participants exercise iterative thinking when deciding whether they want to undertake investment or not: i) there should be the greatest frequency of coordination in the UNIFORM A treatment; and ii) coordination will be smallest in the NON-UNIFORM treatment.

Testing these two sets of hypotheses enable us to identify explicitly the distinct roles of higher-order beliefs versus complexity aversion or learning in influencing the participants' investing decisions. If higher-order iterative thinking is fully used, then coordination will be zero in the NON-UNIFORM treatment, but not in the UNIFORM A or UNIFORM C treatments. If higher-order thinking is used, but not at the level predicted, then there will be decreased coordination in the NON-UNIFORM treatment due to Agents L, but the level of coordination would still be lower than the UNIFORM A treatment. If agents fail to take into account the perspectives of others, then coordination will be equal over all treatments, and should be equal to the within-subject Part II benchmark. Last, if agents are complexity averse and do not use higher-order thinking, then coordination will be equal over all treatments, but less than the within-subject Part II benchmark.

4. The Results

4.1 Descriptive Statistics

We did not find any unusual differences between sessions and thus report the combined results. When agents have knowledge of the outcome, the behavior mirrors Claim 1 (a), i.e., when the outcome is known to be favorable (i.e., peach for Agent P and lemon for Agent L), participants chose to invest, and when the outcome is known to be unfavorable, they do not. This is true in all parts of all treatments. The fundamental assumptions underlying the behavior of uninformed participants inherent in the first portion of eq. (1) are consistent with the behavior observed. We do not find any significant differences over treatments where participants were informed, and report the combined results in Figure 1 (a). Hereafter we focus upon behavior when participants are not informed.

We do not predict or find any significant differences over treatments for Parts I and II (Kruskel-Wallis rank test, $H(2)=0.988$, $p = .613$), and report the combined results in Figure 1 (b). Lacking knowledge of the outcome participants in Part I are less likely to invest when the payoff table was C, suggesting risk aversion may hinder investment when the expected payoff is at the lowest value. In Part II investment also occurs most frequently when the payoff table is A, and least when the payoff table is C.

In Part III we find behavior varies over treatments when participants are uninformed, so report the results for each treatment separately in Figure 1 (c). We find significant differences between the NON-UNIFORM and UNIFORM treatments that we describe in section 4.3.

In order to falsify Hypotheses 1 we estimate the level of iterative reasoning by comparing Part II and Part III decisions within the NON-UNIFORM treatment. Next, in order to falsify Hypotheses 2 (that complexity aversion or learning might solely influence within-subject behavior), we compare PART III decisions and coordination across the three treatments. Last we provide further evidence of the level of iterative thinking by examining a log-likelihood model of the NON-UNIFORM treatment's data that includes a provision of risk preferences.

[Insert Figure 1 about here]

4.2 Support for H1: Level of iterative reasoning

We analyze behavior within participant by comparing the average investing decision by a participant for each part. We use each subject's average behavior over all rounds within a part as a single observation and, unless stated otherwise, report the statistical results of the Wilcoxon matched-pairs signed-ranks test. The mean of the average participant investing rate is reported in Table 3 Panel A. In Part I behavior is consistent with risk aversion.[11] A risk-neutral participant will invest in all payoff tables. While investment differs insignificantly between payoff tables A and B (Mean or M = .84 for A, M = .80 for B, and p-value or p = .096), investment is lowest when the payoff table is C (M = .55, p < .01 compared to when the payoff table was B).

For Part II there is not a unique equilibrium prediction for payoff tables A and B. Even if uninformed parties might invest, investment is nonetheless contingent upon the other using the same strategy. Investment is significantly greater when the payoff table is A (M = .53 for A, M = .43 for B, p = .038), and significantly lower when the payoff table is C (M = .27, p < .01 compared to payoff table B). Participants invest less frequently in Part II than in Part I as expected given the non-unique equilibrium (p < .01 all payoff tables). The decrease in investment is consistent with the uncertainty that the other may be informed; the introduction of aversion selection decreases the uninformed participant's willingness to invest.

To compare within-subject investment in Part II to that in Part III, we compute a benchmark rate using Part II data for each participant. To illustrate, from Part II behavior we computed the mean of the participant's average investing rate when the payoff table is A, again when the payoff table is B, and average the two rates to form a benchmark rate. For the NON-UNIFORM and UNIFORM C treatments we compare the benchmark with a participant's investment in Part III when the partition is *{A, B}* and the payoff table is equally likely to be A or B. A similar construct is computed for the partition *{B, C}* and used as a benchmark for the NON-UNIFORM and UNIFORM A treatments. There are four incidences where a benchmark cannot be constructed as an uninformed investing decision is not observed in Part II because private knowledge of the outcome is stochastic.

Examining Agents P in the NON-UNIFORM treatment, the average rate is greater for the partition *{A}* (M = .57 for *{A}* and M = .24 for *{B, C}* with p < .01). Investment does not differ significantly from the Part II benchmarks (M = .53 for Part II versus .57 for Part III with p = .18,

[11] Consistent with this conjecture, an examination of the post-experiment questionnaire reveals participants cite risk as a reason not to invest.

and M = .35 for Part II versus .24 for Part III with p = .25 for *{A}* and *{B, C},* respectively). If higher-order beliefs predictions held at the highest level of iteration in our thought-exercise, neither signal should yield investment, yet the investing rate is greater than fifty percent for *{A},* albeit less than twenty-five percent for *{B, C}.* As shown in Table 2, the result of no difference between the Part II benchmark and Part III behavior by an Agent P in the NON-UNIFORM treatment is consistent with either one or two iterations by Agent P, but not with three iterations. As such, we reject Hypothesis 1 (c).

Examining Agents L in the NON-UNIFORM treatment, the investment is smallest for *{C}* for Part III, but the difference is not statistically significant (M = .38 for *{A, B}* and M =. 32 for *{C},* p = .60). Investment for signal *{C}* is similar to Part II (M =.27 and .32 for Parts II and III respectively with p= .24). However, comparing investment for signal *{A, B}* to the Part II benchmark, investment significantly decreases for Part III (M = .48 and .38 for Parts II and III, respectively, with $p < .01$). As shown in Table 2, a difference between the Part II benchmark and Part III behavior is consistent with either one or more iterations, but inconsistent with no iterations. As such, we reject Hypothesis 1 (a).

Given this difference for *{A, B}* for Agent L, but no difference for *{B, C}* for Agent P, we find support for Hypothesis 1 (b) that agents do exercise a moderate level of higher-order beliefs thinking, consistent with two iterations, but not to the highest level.

[Table 3 about here]

Examining Part III of the UNIFORM A treatment, the average rate is also greater for the partition *{A}* (M = .62 for *{A}* and M = .38 for *{B, C},* N = 24,p = .025). Investing does not significantly differ from the appropriate Part II benchmarks (*{A}* : M = .62 for Part II and .62 for Part III, N = 23, p = .85; *{B,C}* : M = .34 for Part II and .38 for Part III , N = 23, p = .55).

Examining Part III the UNIFORM C treatment, the rate was significantly smaller for *{C}* than for *{A, B}* (M = .27 for *{C}* and M = .45 for *{A, B},* N = 24, p = .032). Investing does not significantly differ from the appropriate Part II benchmarks (*{A, B}* : M = .50 for Part II and .45 for Part III, N = 23, p = .34 ; *{C}* : M = .18 for Part II and .27 for Part III, N = 23, p = .07).

4.3 Support for H2: Alternative Explanations of Complexity Aversion and Learning

To evaluate the behavior across treatments, we fit random-effects logit models where each participant is a panel member of the data set with repeated observations. We restrict our analysis to Part III.

The first regression models the choice to invest when the participant is uninformed and faced with the partitions *{A}*, *{B, C}* across the NON-UNIFORM and UNIFORM A treatments. We estimate the following logit regression:

Prob(Invest=1)= f(UNIFORM, 2ELEMENT, INTERACTION, TIME, Constant)+Error

Invest=1 is the event investment happens. The dummy variable UNIFORM is 1 when the treatment is UNIFORM A and 0 otherwise, and the dummy variable 2ELEMENT is 1 when the partition is *{B, C}* and 0 otherwise. The dummy INTERACTION is 1 if the treatment is UNIFORM A and the partition is *{B, C}* and 0 otherwise. Last, the variable TIME is 1 if the round was 1, 1/2 if the round was 2, 1/3 if the round was 3, etc. to capture any learning or time trends.[12] The results are reported in Table 4. As the coefficient is insignificant on UNIFORM, we fail to find any difference in investment when seeing the partition *{A}* between treatments. The significant and negative coefficient on 2ELEMENT illustrates the reduced probability of investment when seeing *{B, C}* compared to *{A}* in the NON-UNIFORM treatment. The significant and positive coefficient on INTERACTION illustrates the increased rate of investment when seeing *{B, C}* in the UNIFORM A treatment compared to the NON-UNIFORM treatment. The insignificant coefficient on TIME illustrates we fail to find any change in the probability of investment over time.

[Table 4 about here]

The second regression models the choice to invest when the participant is uninformed and using the partitions *{A, B}*, *{C}* across the NON-UNIFORM and UNIFORM C treatments. We estimate the following logit regression:

[12] We also ran the model with the dummy variable TIME equal to the round in Part III. The overall fit of the model and predictors' significance was insignificant between the options. Results available from the authors on request.

Prob(Invest=1)= f(UNIFORM, 2ELEMENT, INTERACTION, TIME, Constant)+Error

Invest=1 is the event investment happens. The dummy variable UNIFORM is 1 when the treatment is UNIFORM C and 0 otherwise, and the dummy variable 2ELEMENT is 1 when the partition is *{A, B}* and 0 otherwise. The dummy variable INTERACTION is 1 if the treatment is UNIFORM C and the partition is *{A, B}* and 0 otherwise. The dummy variable TIME is identical to the prior regression. The results are reported in Table 5. As the coefficient is insignificant on UNIFORM, we fail to find any difference in investment when seeing the partition *{C}* between treatments. The insignificant coefficient on 2ELEMENT illustrates we fail to find any difference in probability of investment when seeing *{C}* compared to *{A, B}* in the NON-UNIFORM treatment. The significant and positive coefficient on INTERACTION illustrates the increased rate of investment when seeing *{A, B}* in the UNIFORM C treatment compared to the NON-UNIFORM treatment. The marginally significant coefficient on TIME illustrates we find some weak evidence of change in the probability of investment over time.

[Table 5 about here]

As the coefficients upon the interaction dummies shown in Table 4 and Table 5 are both significant and positive, we find support for Hypothesis 2 (b), but not Hypothesis 2 (a). Holding experience constant over treatments, we found that in a non-uniform accounting system, where higher-order thinking is invoked, there was a significant reduction in the willingness of a participant to invest compared to a uniform accounting system. Conditional upon seeing *{A, B},* it was 14 times more likely an uninformed agent would invest in the uniform accounting system than the non-uniform, and conditional upon seeing *{B, C}*, it was 24 times more likely.

To compare the probability of investment within and across treatments, we construct a metric for each participant for Part II and Part III. The probability of investment for a participant indexed by *i* in payoff table/part *p* is given by:

$$
\begin{aligned}
Pr_i^p = & 1/4\{Pr_i^p(U) \times \overline{Pr}^p_{-i}(U)\} + \\
& 1/4\{Pr_i^p(U) \times (\frac{\overline{Pr}^p_{-i}(G)}{2} + \frac{\overline{Pr}^p_{-i}(L_p))}{2}\} + \\
& 1/4\{(\frac{Pr_i^p(G)}{2} + \frac{Pr_i^p(L_p)}{2}) \times \overline{Pr}^p_{-i}(U)\} + \\
& 1/4\{(\frac{Pr_i^p(G)}{2} + \frac{Pr_i^p(L_p)}{2}) \times (\frac{\overline{Pr}^p_{-i}(G)}{2} + \frac{\overline{Pr}^p_{-i}(L_p))}{2}\}
\end{aligned}
$$

where $Pr_i^p(.)$ is the empirically observed probability of coordination, measured over the experiment, for person *i* when uninformed of the outcome (*U*), informed of unfavorable outcome (L_p), or informed of favorable outcome (*G*). Observations where we did not have all three measures for participant were dropped. $\overline{Pr}^p_{-i}(.)$ is the average observed empirical probabilities of coordination measured over the experiment for all others in treatment except person *i* when they are uninformed of the outcome, informed of unfavorable outcome, or informed of favorable outcome.

The intuition for this constructed measure of investment is as follows. For any coordination to occur, both agents must simultaneously elect to invest. There are four scenarios, each with a probability of ¼ to occur. The first one is when neither she nor her partner is informed of the outcome (peach or lemon). The second scenario is when she is uninformed, but her partner is informed that the outcome is favorable (G) or unfavorable (L). The third scenario is when she is informed of the outcome but her partner is not, and the last when both her and her partner are informed of the outcome. Pr_i^p is the average of the four scenarios.

We use this empirically derived measure instead of game outcomes, as the measure is free from the noise caused by stochastic draws of payoff tables and private knowledge of the outcome that would differ over participants, sessions and treatments. We then average coordination for each payoff table within each part and compare the probability of coordination over Part II to Part III for each participant and compare the results using the Wilcoxon matched-pairs signed-ranked test. For the NON-UNIFORM treatment, the probability significantly decreases (M = .04, SEM = .01, N = 41, $p < .01$). For the UNIFORM A treatment, coordination increases, albeit insignificantly (M = .02, SEM = .02, N = 23, p = .48), and for the UNIFORM C treatment coordination increases significantly (M = .05, SEM = .01, N= 23, $p < .01$). A decrease in coordination for the non-uniform accounting system but a (weak) increase for a uniform accounting system is consistent with the predictions shown in Table 2.

Comparing the measure across treatments (see Figure 2), we find the probability of coordination in Part III lowest for the NON-UNIFORM treatment (M = .17, SEM = .01, N = 43), followed by the UNIFORM C treatment (M = .21, SEM = .02, N = 24), and highest for the UNIFORM A treatment (M = .23, SEM = .02, N = 23). The level of coordination differs significantly across treatments (Kruskal-Wallis rank test, $\chi^2(2) = 7.67$, $p = .02$), and this significance is driven by the difference between NON-UNIFORM and UNIFORM A treatments (Wilcoxon, N = 67, $p < .01$). The difference between the UNIFORM A and UNIFORM C treatments was insignificant (N = 47, $p = .39$). The difference in coordination is consistent with Hypothesis 2(c), where a non-uniform accounting system is predicted to produce the smallest gains to coordination.

4.4 Further evidence on higher order thinking: Log-likelihood estimation for the NON-UNIFORM Treatment

To provide further evidence of subjects' use of higher-order thinking, we examine log-likelihood models of the data of the NON-UNIFORM treatment. This allows us to examine risk preferences in the presence and absence of common knowledge and to fit different log-likelihood models of subjects' beliefs. Specifically, we fit the data to four models by incorporating no, one, two, or three levels of iteration as per the aforementioned thought-exercise shown in Table 2.

We model subjects' utility of payoff as $U(y) = 1\text{-}exp(-\rho y)$ where ρ captures risk preferences and *y* represents monetary payoff. Notice her utility function exhibits constant absolute risk aversion. The expected utility is a function of the subject's information (payoff table, private signal, and outcome), as well as the assumed strategy of the other (denoted as 'he'). Note the models yield different predictions only for Part III:

Model 0: The subject behaves as if the other acts exactly the same as she does. As such she disregards her partner's possible signal from his accounting system. Instead she considers only what she believes the payoff tables could be as per her accounting system.

Model 1: The subject plays a best response to a belief that her partner is using a Model 0 strategy.

Model 2: The subject plays a best response to a belief that her partner is using a Model 1 strategy.

Model 3: The subject plays a best response to a belief that her partner is using a Model 2 strategy.

The probability that a subject chooses to invest is modeled as $P_k(I,\lambda,\rho)$, where I is the information set (i.e., outcome when informed, payoff table or signal value), and λ is a precision parameter. The higher the precision parameter, the more likely the choice with higher expected utility (EU) will be taken. When this parameter is zero, the probability is uniform. Following Wilcox (2011), we use a logit-type probability function scaled by the maximum obtainable utility value less the minimum possible utility value of the possible payoff tables given her private information. Use of the scalar, designated as $U_s^* = U(G) - U(L_s)$ where $s \in \{A,B,C\}$, results in the probability function for model $k \in \{0, 1, 2, 3\}$ as:

$$P_k(I, \lambda_k, \rho) = \frac{1}{1 + \exp\left[-\frac{\lambda_k}{U_s^*}\left(EU(I) - U(E)\right)\right]}$$

In calculating the subject's expected utility, when beliefs of others' are applicable (Models 1 through 4), we assume her beliefs of her partner's strategy as $P_{k-1}(I,\lambda,\rho)$. Note this function is at the prior level of iteration, $k-1$, and furthermore we let $\lambda_{k-1} \to \infty$, and thus our agents are modeled with a belief that the partner is using pure strategies.[13] The log-likelihood of a subject i's choice probabilities over the 35 round experiment, Xi, is given by:

$$LL_k(\rho, \lambda | X_i) = \sum_{n=1}^{35} \ln\Big(x_n^i P_k(I_n, \lambda, \rho) + (1 - x_n^i)(1 - P_k(I_n, \lambda, \rho))\Big)$$

where x_n^i equals one if subject i in round n chose to invest and zero otherwise.

[13] To illustrate the resulting value of the probability function, consider the function $P_k(I,\lambda,\rho)$ for Part I when the payoff table is A. Using a risk parameter of $\rho = .09$ and precision $\lambda = 11$ the function yields .90. When $\lambda \to \infty$, then $P_k(I, \lambda, 1/2) \to 1$ resulting in a pure strategy.

The estimation results of log-likelihood function summed over all subjects are shown in Panel A of Table 6. The results are supportive of the intuition of the prior analysis: subjects' trading is consistent with iterated beliefs of others' strategies but not to the highest level of iteration predicted. The values of ρ given by the models are not significantly different from each other.

Comparing the three models, we find Model 2 yields the best fit, consistent with Hypothesis 1 (b). Compared to the data, Models 0 and 1 predict too much investment from Agents L with signals *{A, B}*, while Model 3 predicts too little investment for Agents P with signals *{A}*. Of course not all subjects may iterate to the same level, nor may all subjects use the same level of iteration for all decisions. So we also examine a mixture model (Model M), where some fractions of the choices, π_k, are made using a particular model. The log-likelihood of a subject's choice probabilities over the experiment, X_i, is given by:

$$LL(\pi, \rho, \lambda_k | X_i) = \sum_{n=1}^{35} \ln \sum_{k=0}^{3} \pi_k \Big(x_n^i P_k(I_n, \lambda_k, \rho) + (1 - x_n^i)(1 - P_k(I_n, \lambda_k, \rho)) \Big)$$

As we found no statistically significant difference between the risk parameter generated for Models 0 - 3, we construct Model M using a single risk parameter. The estimation results of the Model M log-likelihood function summed over all subjects are shown in Table 6 Panel B.

[Table 6 about here]

The results show that the majority of decisions display behavior consistent with two iterations. Model M is inferior to Models 1 and 2 in terms of lesser log-likelihood, and inferior to Models 0-2 in terms of higher Akaike information criteria (AIC) and Bayesian information criteria (BIC). Any increase in fit Model M has compared to Model 0 is negated when penalizing for more parameters. Model 2 emerges as the most likely candidate for predicting behavior.

4.5 Discussion

We find the introduction of strategic uncertainty, due to non-uniform accounting measurement rules of fundamental values, was negatively associated with an individuals' election to coordinate and capture economic gains (section 4.2). However, this decreased behavior was not as dire higher-order models would predict. These results are consistent with Kübler and Weizsäcker (2004) and Heinemann, Nagel, and Ockenfels (2004), whose findings suggest participants do not follow higher-order predictions to the extent of theory; instead a cognitive model with limited levels of reasoning best explains aggregate behavior.

By examining behavior in Part III between treatments we clearly show that strategic uncertainty decreased coordination while controlling for non-modeled distributional preferences, risk preferences, complexity aversion and learning. Similar to Rangvid, Schmeling and Schrimpf (2013), we find alternative theories cannot fully explain empirical results, leaving higher order thinking as a non-falsified theory of behavior. The effect upon coordination due to non-uniform accounting measurements is both statistically significant and economically non-trivial (section 4.3).

We observe not only changes in behavior using within-subject measures, but also changes in behavior between-subjects when uniformity in accounting measurement is manipulated. Because both within- and between-subjects measures are consistent with theoretical prediction, we argue participants do not play randomly, but arrive at strategies via careful consideration of iterative strategies, appearing to adopt a best response to their beliefs of other players.

5. Conclusion

There have been long debates whether accounting measurement rules should be more uniform. The extant literature on uniformity versus non-uniformity illustrates the trade-off between the improved information communication and opportunistic manipulation by the management (e.g., Dye and Verrecchia, 1995). We posit that non-uniform accounting measurement may generate dispersion in beliefs that gives rise to higher-order belief reasoning, which potentially has efficiency implications that we explore in this study.

Higher-order belief models predict behavior in settings that the behavior depends not only upon economic fundamentals, but also upon a person's beliefs regarding the beliefs of others (or strategic uncertainty). The models hold insight into phenomena regularly cited as evidence of inefficient markets or limited rationality, while in fact, the observed behavior may not necessarily depart from rationality, but may be due to strategic uncertainty. The higher-order belief reasoning is appealing and makes intuitive sense in scenarios that require strategic coordination among participants, and has been applied in theory to various economic settings such as capital market pricing and loan rolling over decisions to generate new insight into the role of beliefs in resource allocation. However, to the best of our knowledge no research empirically examines the implication of such a behavioral regularity for the design of accounting rules.

We generate a setting where two partners have differential accounting estimates of the underlying economic fundamentals due to non-uniform accounting measurement rules. In such a setting, predictions of rational strategies can be constructed via iterations of a thought exercise, and the number of iterations leading to equilibrium is, in a crude sense, feasible. We use parameters in which coordination is expected to occur when partners base their decision only on their own beliefs of the fundamental uncertainty about the value of the project, while higher-order of iterative reasoning of the beliefs of their coordinating partners, and their partners' beliefs of their beliefs, and so on, prevents such coordination to occur. Our experimental design allowed us to set aside various behavioral phenomena and examine decisions across different regimes as to isolate the effects of strategic uncertainty in a simple, albeit novel, setting. Experimental behavior was consistent with theory, where a uniform accounting measurement system would result in higher frequency of coordination and social welfare than a non-uniform accounting measurement system. We find evidence supporting the models' prediction of the breakdown of coordination, and thus welfare due to differential information about the accounting measurements of the value of the project when accounting measurements are non-uniform across the coordinating partners. We find that a limited number of iterations predict overall behavior, but at the same time, the majority of decisions display some level of iteration. In our setting uniform accounting measurement did enable higher levels of coordination and thus provide for higher efficiency and social welfare. We provide clear evidence that the inefficient outcome is not due solely to complexity aversion behavior, learning or decreased information content. While higher-order beliefs unarguably play a significant role, the dire predictions of coordination failure were not realized.

The results suggest that higher-order beliefs thinking may have important implications on the design of accounting standards, such as uniformity across firms' measurement rules and transparency of accounting information. Indeed the literature has shown that when higher-order thinking is in place, information may not always be value enhancing (Morris and Shin 2002, Anctil, Dickhaut, Kanodia and Shapiro 2004). Given how information partitioning can destroy welfare, even when accounting systems are uniform, a natural extension is to examine the optimal accounting system when the values of lower payments or opportunity costs are stochastic rather than static. Also, it remains an open question as to whether the ability to communicate would improve coordination as was experimentally examined by Qu (2013) in a setting lacking adverse selection. We leave this to future research.

APPENDIX: PROOFS AND DERIVATIONS

Proof of Claim 1:

Parts (a), (b), and (c) are straightforward. For Part (d), the maximum ex-ante probability of trade is calculated as (for readers: please replace buyer with Agent P and seller with Agent L):

$$\underbrace{\frac{1}{2}\times\frac{1}{2}}_{\text{buyer informed of peach outcome}} \times \underbrace{\frac{1}{2}}_{\text{seller ignorant}} + \underbrace{\frac{1}{2}\times\frac{1}{2}}_{\text{both buyer and seller ignorant}} + \underbrace{\frac{1}{2}\times\frac{1}{2}}_{\text{seller informed of lemon outcome}} \times \underbrace{\frac{1}{2}}_{\text{buyer ignorant}} = \frac{1}{2}$$

□

Proof of Claim 2:

To arrive at the equilibrium behavior on uninformed agents, we demonstrate the iterative thinking inherit in higher-order beliefs by stepping through a thought-exercise. The exercise illustrates alternative non-equilibrium benchmark behavior in the case that participants do not exhibit iterative thinking to the extent needed to arrive at equilibrium.

Derivation of Predictions of Iterative Thinking When Partitions are Not Uniform

Imagine an uninformed agent (i.e., uninformed of the outcome, peach or lemon) knows the payoff table of nature. If she invests, assuming the other (he) also invests when he is either uninformed or when he knows his payoff is *G*, her expected payoff in payoff table *i* is $\frac{1}{2}\left[\frac{1}{2}L_i + \frac{1}{2}\mathrm{E}\right] + \frac{1}{2}\left[\frac{1}{2}\mathrm{L_i} + \frac{1}{2}\mathrm{G}\right]$, where the value $\mathrm{L_i}$ depends upon the payoff table. Using the aforementioned parameters shown in Table 1 (A), the net expected value (less opportunity cost *E=5*) is 0.35, 0.25, and -0.25, for payoff tables A, B, and C, respectively. On the other hand, if she invests, but the other only invests when he knows the payoff is G and does not when uninformed, her expected payoff in payoff table *i* is $\frac{1}{4}\mathrm{L_i} + \frac{3}{4}\mathrm{E}$. The net expected value is -0.45, -0.50, and -0.75 for payoff tables A, B, and C, respectively.

We start with a base-level where the decision maker disregards the signal the other agent may have received. Furthermore, she expects her partner to follow the same strategy. Agent P receives either *{A}* or *{B, C}*. When she receives *{A}*, she knows the payoff table is A, and decides to invest as the net expected payoffs are greatest when investing (comparing net payoff to forgone opportunity). When she receives *{B, C}*, she knows that the payoff table is B or C with equal probability, and she must accept or reject both. She will invest (weakly) as the net expected payoffs are 0.25 or -0.25 for payoff tables B and C, respectively. Agent L receives either *{A, B}* or *{C}*. When she receives *{A, B}*, she knows the payoff table is A or B with equal probability, and the net expected payoffs of investing are 0.35 and 0.25 for payoff tables A and B respectively, so she invests. When she receives *{C}* she knows the payoff table is C and she does not invest, as the net expected value is negative. These strategies are summarized in the first row of Table 2.

Now we move to one iteration where the decision maker considers the signal value the other agent might have received given her own signal, and constructs a best response to the strategies shown in the first line of Table 2. When Agent P receives *{A}* she knows the other received *{A, B}*, and since he invests when uninformed, she invests as the net expected payoff is positive. When she receives *{B, C}*, she knows the other sees either *{A, B}* and invests, or *{C}* and does not invest, and the net expected payoffs from investment are either 0.25 or -0.75 for payoff tables B and C, respectively, so she does not invest. When Agent L receives *{A, B}*, she knows the payoff table is either A and the other sees *{A}* and will invest, or the payoff table is B and the other sees *{B,C}* and also will invest. The net expected payoffs are 0.35 and 0.25 for payoff tables A and B, respectively, so she will invest. When she receives *{C}* she knows the payoff table is C, so she does not invest. These strategies are summarized in the second row of Table 2.

In the next iteration the decision maker considers what signal the other agent believes the decision maker received, and constructs a best response to the strategies summarized in the second row of Table 2. When Agent P receives *{A}*, she knows the other player sees *{A, B}* and he will invest, so she will invest, as the net payoff is positive. As in the prior iteration, when she receives *{B,C}* she does not invest. When Agent L receives *{A,B}*, she know Agentt P sees *{A}* and invests, or sees *{B,C}* and will not invest, and the net expected payoffs are 0.35 or -.0.50, so she will not invest. As in the prior iteration, she will not invest when she receives *{C}*. These strategies are summarized on the third row of Table 2.

The last iteration considers what beliefs the other agent has of the decision maker' belief about what he received, and constructs a best response to the strategies shown in the third row of Table 2. When Agent P receives *{A}*, she knows the other player received *{A, B}* and does not invest, so she does not invest. As in the last iteration Agent P will not invest when receiving *{B,C}*, and Agent L will not invest for any partition received. This is last iteration of interest as all further iterations yield the same unique prediction of no investment for all signal values. These strategies are summarized in the last row of Table 2. Hence, when agent L sees *{A}*, she knows that the outcomes imply coordination is possible, and she knows the buyer also knows coordination is possible, but she does not know that the other knows she knows, so coordination collapses. Nonetheless, no investment is predicted to occur as coordination requires at least one uninformed agent, and we show that an agent will not choose to invest when uninformed.

Derivation of Predictions when Partitions are Uniform

As argued before, we restrict our discussion to the case of uninformed agents. First, both agents see the partitions *{A, B}* and *{C}*. If agents see *{C}* then eq. (1) is false, and the unique prediction is one of no-investment. However, when the agents see *{A, B}* then both know that eq. (1) is satisfied, and both know the other knows that eq. (1) is satisfied. As such, an uninformed agent might invest if the other invests, giving a non-unique prediction of investment. For risk neutral agents, the equilibrium prediction of investment when seeing *{A, B}* and not invest when seeing *{C}* dominates the alternative no-investment equilibrium.

Second, both agents see the partitions *{A}* and *{B, C}*. If agents see *{A}* then eq. (1) is true, so the non-unique prediction is one of coordination. When agents see *{B, C}*, then both agents know the payoff table is either B or C with equal probability, and know the other agent also knows. The expected value to investment, assuming the other invests when uninformed, is $\frac{1}{2}\left[\frac{2L_b+E+G}{4}\right]+\frac{1}{2}\left[\frac{2L_c+E+G}{4}\right]$, which is equal to E given the parameter values, giving a non-unique prediction of investment. For risk neutral agents, the equilibrium prediction of always investing weakly dominates investing when seeing *{A}* and not investing when seeing *{B, C}*, which dominates the alternative no-investment equilibrium.

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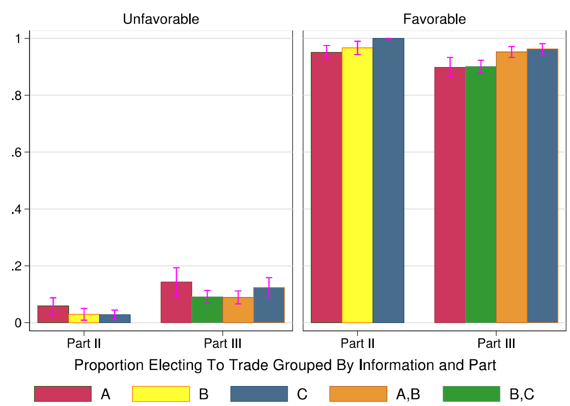
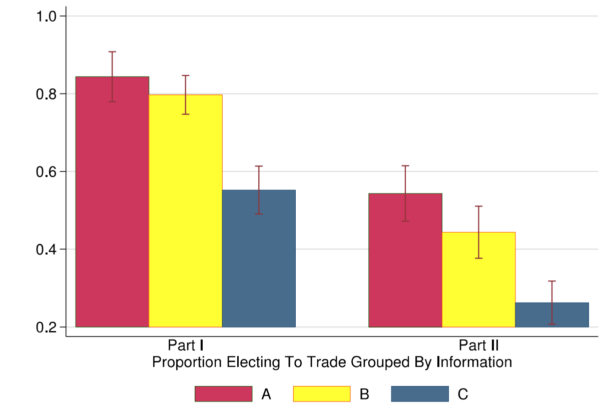
Figure 1: Observed Investment. Mean and Standard Error Shown

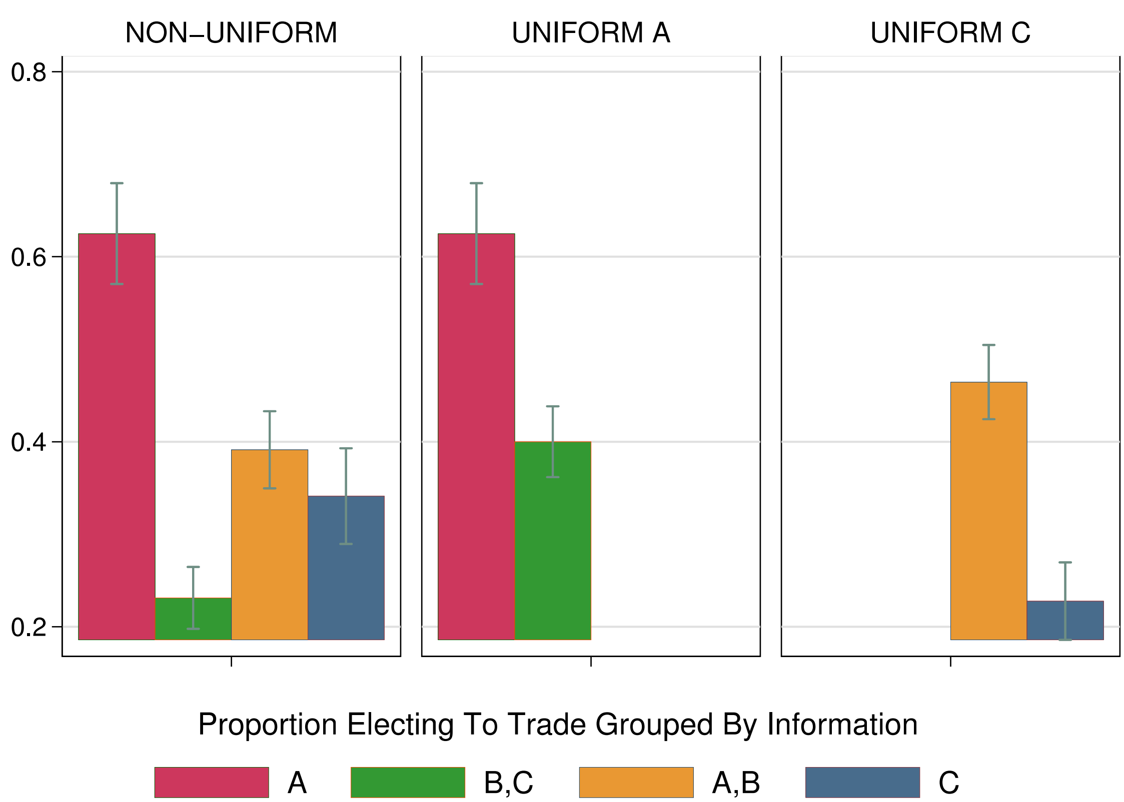
Panels (A) – (C) report the raw proportions of choices for illustrative purposes. For statistical testing in Section 3 we use the average per participant as a unit of observation.



(a) Participants Informed of Outcome

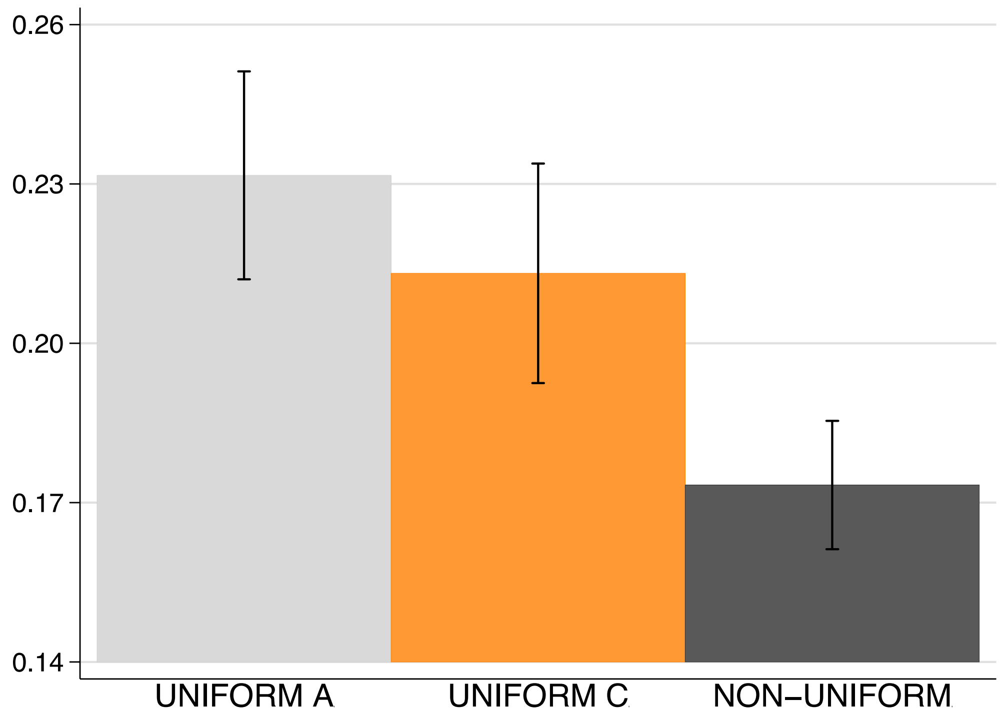


(b) Uninformed of Outcome - Parts I and II



(c) Uniformed of Outcome in Part III over Treatments

Figure 2: Probability of Coordination in Part III by Treatment



NOTE: Probability of coordination constructed using empirically observed behavior at a select outcome node.

Table 1: Model setup and experimental design

(a) Cost and Payoff Values for All Parts of All Treatments

Payoff Table	Probability Of Table	Opportunity Costs (E)	Agent L's Net Payoff		Agent P's Net Payoff	
			Lemon (G)	Peach (L)	Lemon (L)	Peach (G)
A	1/3	5	10	3.2	3.2	10
B	1/3	5	10	3	3	10
C	1/3	5	10	2	2	10

(b) Accounting Partitions Used in Part III of Each Treatment

	Payoff table		
Treatment	A	B	C
UNIFORM A	*{A}*	*{B, C}*	*{B, C}*
UNIFORM C	*{A, B}*	*{A, B}*	*{C}*
NON-UNIFORM			
Agent P	*{A}*	*{B, C}*	*{B, C}*
Agent L	*{A, B}*	*{A, B}*	*{C}*

Table 2: Iterations Leading to an Equilibrium Prediction per Treatment

	Partition Seen			
	{A}	*{B,C}*	*{A,B}*	*{C}*
UNIFORM A				
Base Level (Equilibrium)	Invest	Invest		
UNIFORM C				
Base Level (Equilibrium)			Invest	Do Not Invest
NON-UNIFORM				
Base Level	Invest	Invest	Invest	Do Not Invest
One Iteration	Invest	Do Not Invest	Invest	Do Not Invest
Two Iterations	Invest	Do Not Invest	Do Not Invest	Do Not Invest
Three Iterations (Equilibrium)	Do Not Invest	Do Not Invest	Do Not Invest	Do Not Invest

NOTE: The table predicts uninformed agents behavior in Part III for a given signal partition observed. We relegate the derivation of the equilibrium predictions to the Appendix. We show the non-unique investing equilibrium for the UNIFORM A and UNIFORM C treatments.

Table 3: Mean Average Investing Rates when Uniformed of the Outcome

A Parts I and II – All Treatments

		Payoff table		
		A	B	C
Part I	Mean	.84	.80	.55
	Error of the Mean	(.04)	(.03)	(.04)
	Observations	96	96	96
Part II	Mean	.53	.43	.27
	Error of the Mean	(.05)	(.05)	(.04)
	Observations	96	95	93

B Part III

		Partition			
		{A}	*{B,C}*	*{A,B}*	*{C}*
NON	Mean	.57	.24	.38	.32
UNIFORM	Error of the Mean	(.10)	(.07)	(.08)	(.08)
	Observations	24	24	24	24
UNIFORM A	Mean	.62	.38		
	Error of the Mean	(.08)	(.09)		
	Observations	24	24		
UNIFORM C	Mean			.45	.27
	Error of the Mean			(.09)	(.08)
	Observations			24	24

Table 4: Logit Regression Analysis of Invest When Uninformed Agents See *{A}* or *{B, C}*

Predictor	Coefficient	Std. Error	P-value	Odds Ratio
UNIFORM	0.068	1.034	.948	8.137
(1 if treatment is UNIFORM A)				
2ELEMENT	-3.483	0 .571	< .001	0.094
(1 if partition is *{B, C}*)				
INTERACTION	1.853	0.692	.007	24.798
(1 if treatment is UNIFORM A and partition is *{B, C}*)				
TIME	0.582	0.065	.367	6.332
(Period)				
Constant	0.762	0.752	.311	

N = 485; Groups = 48; observations per group: average =10.1, min. = 6, max. = 16

Log likelihood = -212.54

Wald $\chi^2(4)=50.08$, $p < .001$

Likelihood-ratio test of rho equal to zero; $ChiBar^2(01) = 181.42$, $p < .001$

Table 5: Logit Regression Analysis of Invest When Uninformed Agents See *{A, B}* or *{C}*

Predictor	Coefficient	Std. Error	P-value	Odds Ratio
UNIFORM	-1.089	0.941	.247	2.126
(1 if treatment is UNIFORM C)				
2ELEMENT	0.305	0.385	.428	2.887
(1 if partition is *{A,B}*)				
INTERACTION	1.490	0.692	.012	14.105
(1 if treatment is UNIFORM C and partition is *{A,B}*)				
TIME	1.242	0.700	.076	13.651
(Period)				
Constant	-1.283	0. 668	.055	

N = 479; Groups = 48; observations per group: average =10.0, min. = 4, max. = 14

Log likelihood = -226.03

Wald $\chi^2(4)$=16.21, p = .0027

Likelihood-ratio test of rho equal to zero; $\text{ChiBar}^2(01)$ = 161.66, p < .001

Table 6: Log-likelihood Results of Models of NON-UNIFORM Treatment

(a) Fitted Parameters for the Log-Likelihood Models

	Model 0	Model	Model 2	Model 3	Model M
Minimized Value of LL	-813	-811	-808	-877	-812
Precision Parameter λ_k	8.41	9.07	10.48	9.88	*See below*
Risk Parameter ρ	0.08	0.10	0.09	0.09	0.06
AIC	1,629	1,627	1,621	1,759	1,638
BIC	1,633	1,630	1,625	1,763	1,651
Parameters for Model M:					
Proportion π_k	0.06	0.09	0.83	0.02	
Precision Parameter λ_k	28.02	7.69	10.90	22.39	

(b) Models' Predicted Probability $P_k (I , \lambda_k , \rho)$ in Part III When Uniformed per Signal

	Model 0	Model 1	Model 2	Model 3	Observed
{A}	0.34	0.50	0.52	0.31	0.62
{B, C }	0.30	0.30	0.30	0.30	0.23
{A, B}	0.42	0.48	0.39	0.40	0.39
{C }	0.30	0.20	0.20	0.20	0.34