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Information (non)aggregation in markets with costly signal acquisition

Brice Corgnet[a], Cary Deck[b,c], Mark DeSantis[c], David Porter[c,*]

[a] EM Lyon Business School, 23 Avenue Guy de Collongue, Écully 69130, France
[b] University of Alabama, Tuscaloosa, AL 35487, USA
[c] Chapman University, 1 University Drive, Orange, CA 92866, USA

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ABSTRACT

Markets are often viewed as a tool for aggregating disparate private knowledge, a stance supported by past laboratory experiments. However, traders' acquisition cost of information has typically been ignored. Results from a laboratory experiment involving six treatments varying the cost of acquiring signals of an asset's value suggest that when information is costly, markets do not succeed in aggregating it. At an individual level, having information improves trading performance, but not enough to offset the cost of obtaining the information. Although males earn more through trading than females, this differential is offset by the greater propensity of males to buy information such that total profit is similar for males and females. Looking at individual skills, we find that higher theory of mind is associated with greater trading profit, greater overall profit, and an increased likelihood of acquiring information while cognitive reflection is associated with greater profit but not a greater propensity to acquire information.

1. Introduction

The notion that markets aggregate private information has been put forward since Hayek (1945) and Muth (1961), but it was Plott and Sunder (1988) who introduced the canonical experimental market for studying such a phenomenon.[1] The experimental results in their paper suggest that markets do aggregate individual traders' disparate information. Since the publication of those early results, there has been considerable attention given to the predictions such markets can yield both in and out of the laboratory.

With respect to field studies, while Chen and Plott (2002) and Gillen et al. (2017) discuss the successful use of information aggregation mechanisms at Hewlett-Packard and Intel, respectively, firms such as Google, Microsoft, Yahoo, and IBM also make use of internal markets for aggregating information (see Cowgill et al., 2009). Pennock et al. (2001) document the ability of the Hollywood Stock Exchange to forecast the success of yet to be released movies, and Berg and Rietz (2003) documents the success of the Iowa Electronic Market for predicting the outcomes of US elections.[2] In fact, the evidence of mar-

* Corresponding author.
E-mail address: dporter@chapman.edu (D. Porter).

[1] Plott and Sunder (1982) has a similar structure, but investigates information dissemination (some traders are fully informed of the asset's true value, while others are uninformed) rather than aggregation (all traders are partially informed of the asset's true value). Information dissemination is also sometimes referred to as information amplification (e.g., Bossaerts et al., 2014).

[2] The success is not universal (see e.g., Jacobsen et al., 2000 ; Brüggelambert, 2004; Corgnet et al., 2015; Camerer et al., 2016).

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kets aggregating information is sufficiently strong that a large group of scientists called for the relaxation of various laws to facilitate greater use of prediction markets (see Arrow et al., 2008).

Deck and Porter (2013) provides a recent survey of the experimental evidence for information aggregation. Much of this previous experimental work has either explicitly assumed that traders are endowed with information or implicitly assumed that individual traders have collected information in the course of their normal activities. These are non-trivial assumptions. If markets are completely efficient so that prices fully reflect all information held by traders, then one would never incur a cost to acquire new information solely for the purpose of trading as the cost of the information could not be recovered (Grossman and Stiglitz, 1980). The implication is that no trader would seek out costly information and thus such information could not be reflected in the price. The costly collection of information requires that markets either do not fully reflect all available information or only do so gradually.[3]

The experimental literature directly exploring the effect of costly information acquisition on market aggregation is limited to a few studies. This literature includes the seminal papers of Sunder (1992) and Copeland and Friedman (1992) as well as the more recent works of Huber et al. (2011), Page and Siemroth (2017), and Asparouhova et al. (2017). Sunder (1992) introduces information cost in two ways. One is to auction off information to the highest bidder. With repetition, the price of information falls toward zero, and this information is reflected in the price of the underlying asset. The findings of Copeland and Friedman (1992) are consistent with Sunder (1992). The case in which the amount of information in a market is fixed may not represent most of the prediction markets previously described. An alternative approach that was also explored in Sunder (1992) enables any trader to purchase information at a fixed price. In this setting, Sunder reports that markets do not fully aggregate information (i.e., the prices do not reflect the true asset value) and that those traders who do buy information are able to recoup their investment. While Sunder's results are suggestive, they are based on only six sessions that differ from each other in several potentially important ways including the process determining asset value, the price of information, and the participation of subjects in previous related experiments.

Page and Siemroth (2017) extends Sunder (1992) by studying the effect of both traders' endowments and traders' information heterogeneity on information acquisition, but in an environment with a different information structure. Sunder (1992) considers the case of aggregate certainty in which the collection of all private signals in the market determines the value of the asset with certainty. Actually, the purchase of information in Sunder (1992) transforms a trader into an insider (i.e., a piece of information informs the trader of the true value). We also study the case of aggregate certainty by considering that the asset traded in the market could only take one of three possible values with each private signal stating which of the three values the asset could not take. Any trader possessing two signals would thus have complete information about the asset value. In addition, two traders holding a different private signal would jointly have all the information needed to determine the true value of the asset. By contrast, Page and Siemroth (2017) study the more involved case of aggregate uncertainty using the ball-and-urn setup developed by Anderson and Holt (1997). In that case, all private signals available in the market do not determine the value of the asset with certainty. Under this procedure, signals which are obtained by observing the color of a ball drawn from a two-color urn can never be fully revealing about the actual state of the world because draws are made with replacement. Using experimental markets and theoretical models respectively, Lundholm (1991) and Chen et al. (2006) argue that aggregate uncertainty precludes information aggregation.

The findings of Page and Siemroth (2017) regarding the limited evidence for information aggregation are thus consistent with Lundholm (1991) and Chen et al. (2006). In addition to a baseline, Page and Siemroth (2017) designed a *public draw* treatment in which all traders received the same noisy public signal before deciding whether to acquire further information. The treatment was compared to the baseline in which the initial traders' information was privately held. The authors also considered a second treatment (*high endowment*) in which traders vary in their level of endowment so that half of the traders in the market had a level of cash and shares which was twice higher than in the baseline. In line with their conjectures, the authors show that traders are more likely to acquire information in the *public draw* treatment than in the baseline. Also, traders who received more cash and shares in the *high endowment* treatment acquired more information than the remaining traders.

Huber et al. (2011) also extend the work of Sunder (1992) by considering the case in which traders can buy the possibility to become an insider at an early period in the experiment following the design of Huber (2007) and Kirchler (2010). The authors consider a total of five different information levels which differ in the exact timing in which a trader learns the true value of the asset. In their fixed cost treatments, they consider different values for the cost of being informed early.[4] For each treatment, they only impose that the cost of being informed at an earlier period is lower than the cost of being informed at a later period. In line with Page and Siemroth (2017), they find that informed traders' earnings (net of the cost of information) are lower than uninformed traders' earnings. They also show that an increase in the cost of information significantly decreases the likelihood of traders to purchase information. Finally, they show that an increase in the cost of information led to a decrease in the informational efficiency of markets.

All previous experimental works studied information acquisition in a centralized double auction market. Instead, Asparouhova et al. (2017) assess the extent to which traders acquire costly information in a decentralized setting following the theoretical framework of Duffie et al. (2009). In that setup, which aims at mimicking over-the-counter markets,

[3] Hanson and Oprea (2009) show theoretically that traders would still acquire costly information in the presence of a market manipulator.

[4] The authors also consider treatments in which information is priced using a Vickrey auction.

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