# A Study of Speculation: Do Economic Players Choose Based on Accurate Predictions of Others' Decisions?

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The recent financial crisis that developed in the real estate market illustrates how individuals and groups can neglect to fully analyze the economic environment in which they make decisions. At times, shortsighted strategies are corrected by market forces. In other cases, individual mistakes are simply exacerbated by other miscalculations and, as witnessed in the recent financial upheaval, can lead to unprecedented consequences.

One of the most striking features of the recent crisis was the failure of professional economic players to assess the weaknesses of credit derivatives and consider the potentially negative consequences of speculative strategies. The *Washington Post* reported in 2008 that when AIG Chief Operating Officer Joseph Cassano was asked by a Goldman Sachs analyst about the stability of Financial Products' huge portfolio of credit derivatives, that Cassano "responded with calm and confidence. 'It is hard for us, without being flippant, to even see a scenario within any kind of realm of reason that would see us losing $1 in any of these transactions.'" [1] Cassano's assurance suggests a viewpoint that his firm understood the correct probability of default (zero) while firms trading with them somehow did not. In 2009, AIG set a record by reporting a $60 billion fourth-quarter loss.

Along these lines, many players in the real estate market did not assess the consequences of price increases when making real estate decisions. Generally it was understood that housing prices were rising above their fundamental value, but many players assumed prices would continue to rise and that buying at those prices would be a lucrative strategy. Homebuyers took on mortgages they could not afford, expecting property values to continue to soar, assuming a demand for housing at increasing prices would continue into the future.

Understanding how individuals make simple strategic decisions is the key to understanding market outcomes and helpful in designing institutional structures that correct for inefficiencies. Research into how people play basic strategic games has proven worthy of analyzing and predicting economic phenomena such as fluctuations in the real estate market. Strategic games help us uncover what information people take into account when faced with several alternatives, as well as (and arguably as important) how people expect other agents to react to their decisions. Do people tend to play at Nash equilibrium, in other words, play rationally? To what extent are people strategic? Which begs the question: To what extent do they

[1] "Downgrades and downfall" December 31, 2008, page A01.

anticipate others to be strategic? A large body of evidence born of economic research into decision-making has shown systematic deviations from central predictions of equilibrium analysis in people's choices. This evidence is useful – it suggests individuals typically make mistakes – and it helps to formulate hypotheses on the causes. For example, many studies have shown that people do play strategically but are limited in terms of awareness that others also play strategically. This irrational view of others results in systematic departures from equilibrium behavior, and can influence the market, such as in real estate transactions. Detrimental speculative strategies are one example. They emerge when actors cannot assess the value of a transaction with certainty, and in particular when it is difficult to determine the incentives of other actors. For example, buyers may fail to realize that sellers have superior knowledge about the true value of a property and that they use this knowledge in their decision-making. Or, lenders may not assess the incentives of some buyers to default if and when interest rates rise in the future.

In Brocas et al. (2009), we conducted an experimental study of speculation, and we focused on speculation that can arise for purely informational reasons. We designed a game with private information in which a speculative outcome can arise even though it is not the rational outcome (Nash equilibrium). Resulting data helped determine whether subjects play the Nash equilibrium and, when they do not, the outcome. We also were able to uncover what type of information a subject seeks before making a decision. We did this by tracing attentional data throughout the experiment, with the goal to identify information noted by subjects and how it related to their eventual decisions.

Laboratory techniques were especially suitable for our objectives in this research because such experiments provide data about behavior that cannot be observed directly in the field, and they sharpen tests of theories. The results of the laboratory tests also can provide guidelines for richer theories and new models of individual behavior in trading and other speculative markets. Overall, our analysis points to a need for such new models in real estate markets to help protect the economy from unintended consequences.

## FRAMEWORK OF THE GAME

In the laboratory research, we focused on zero-sum speculation games with private information. Figure 1 shows an example. There are three possible states of the world: A, B, and C. Two players participate and have private information about the state of the world. Player 1 has one of two possible pieces of information: either he knows the state is C for sure, or he knows the state is A or B. Similarly, player 2 either knows the state is A for sure, or he knows the state is B or C. That is, depending on the true state, players believe different things. Players must choose between "bet" or "sure payoff". If they choose "sure payoff" they each earn the number in the upper right "S" for sure (10, in this example). The payoffs from betting for the two players, 1 and 2, are shown in the top and bottom rows. The betting payoffs are only received if *both* players choose to bet (otherwise they each get the sure payoff).

This game can be illustrated in real life in a trade deal between two developers, for example. Let's say developer 1 wants to purchase land from developer 2 to build an apartment complex. The first developer is able to identify conditions yielding medium profits (state C), but does not have the expertise to determine whether the project could yield very high (state A) or very low (state B) profits. By contrast, the second developer can assess whether this particular project will yield high profits (state A) but cannot disentangle between conditions yielding low (state B) or medium (state C) profits. As in figure 1, the net benefits of trade are high for developer 1 and low for developer 2 if the state happens to be A. Conversely, the net benefits of trade are low for developer 1 and high for developer 2 if the state happens to be B.

A remarkable fact about the design of this game is that *no mutually agreed betting should ever take place* if players are rational and think that others are, too. Consider the case of player 1 with information set {A, B}. As far as he is concerned, the state is either A or B. However, he does not know whether player 2 knows for sure the state is A, or believes it is either B or C. However, he should deduce that player 2 will never bet if he knows the true state is A (because 0 < 10), and therefore could expect at most 5 from betting. Therefore, he should not bet (a similar argument implies that player 2 with information set {B,C} should not bet either). Notice also that player 1 makes the wrong decision if he concludes naively that his expected payoff of betting in {A,B} is the average payoff 15, and compares it with the sure payoff (similarly for player 2 with information set {B,C}).

Figure 1.

<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>S = 10</th></tr>
<tr><td>1</td><td>25</td><td>5</td><td>20</td><td></td></tr>
<tr><td>2</td><td>0</td><td>30</td><td>5</td><td></td></tr>
</table>

Milgrom and Stokey (1982) showed that this no-betting property applies to a broad class of zero-sum games with private information, a surprising result dubbed "the Groucho Marx theorem" by Milt Harris (after Groucho's quip that he would never join a club that would deign to have him as a member). The Groucho Marx theorem implies that there should be no speculation based purely on private information.

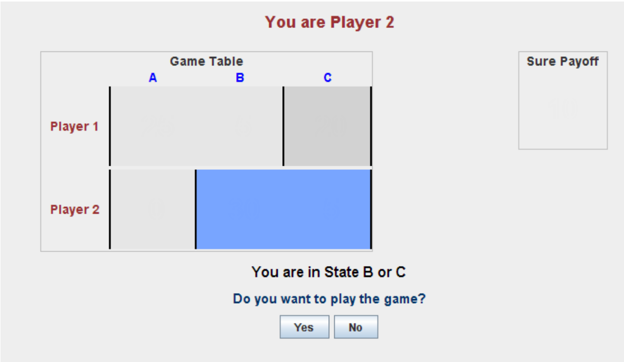
## EXPERIMENTAL FOUNDATION

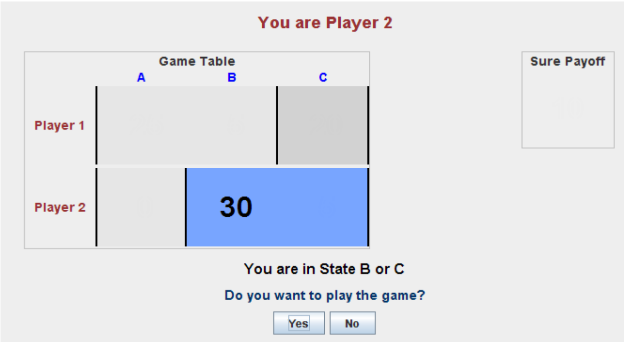
A few experimental studies (see Sonsino et al. (2002), Sovik (2004) and Carrillo and Palfrey (2008)) have looked at behavior in similar games and found substantial rates of betting, even after many repetitions. In other words, speculation does arise when it should not. There are three theories of why there is betting in these cases: (i) Subjects analyze the game carefully but believe that others make mistakes which can be exploited; (ii) subjects analyze the game carefully but make mistakes in making computations or executing strategies; and (iii) subjects do not analyze the game completely.

Theories (i)-(ii) and (iii) make different predictions about the combination of information attended to by subjects and their choices. In theories (i) and (ii), subjects fully analyze the game but believe others make mistakes, or they make mistakes themselves (a failure of logical omniscience, for example). In the limited-rationality theory (iii), subjects may not look at all the payoffs in the game, and their choices will be constrained by their limited attention.

A potentially efficient way to test different theories of strategic behavior is to collect data on both choices *and* the information that people are required to use to behave according to the theory. Attentional data can then be used to test directly whether the cognitive process assumed in the theory is actually being employed. A few studies have used attentional measurement to study information "lookups" in games (see Camerer et al. [1993], Johnson et al. [2002], Costa-Gomes and Crawford [2006]).

Our experiments used a "mousetracking" technique to explore limits of cognition, learning, and related issues. The mousetracking method hides payoff information behind blank boxes; the information can be revealed by moving a mouse into the box and holding the left button down (if the button is released, the information disappears). The following screenshot figures provide an illustration. In this screenshot example, the subject knows he is player 2 and the true state is either B or C (the boxes are highlighted). To identify each of the seven payoffs, he must click on the corresponding box and hold.




We ran two sessions in the SSEL laboratory at Caltech and three sessions in the CASSEL laboratory at UCLA using the Multistage game software with the new mousetracking interface developed at Caltech.

We considered various speculation games with a structure of payoffs similar to that described in Figure 1. However, the information required for reaching a decision varied so that some games were trivial, others were simple, and the remaining games were complex. Trivial games were those games in which a player knew the exact state of the world (e.g. player 1 in state C in figure 1). It is sufficient in that case to look only at the [1C] payoff and compare to the sure payoff [S].

Simple games could be solved after a quick analysis of a few payoffs. These games correspond to Player 1 with information set {A,B}. She must see whether Player 2 will bet in A (by looking at the [2A] payoff of 0) and look at her payoffs [1A], [1B] as well as [S]. This process is strategic because it requires looking at another player's payoff, realizing the different information partition of the opponent (which is explained as part of the instructions and made clear visually), and making an inference assuming the simplest level of rationality (dominance) of the opponent.

Complex games required taking more information into account and more sophisticated reasoning. These games correspond to Player 2 with information set {B,C}. Determining that Player 1 will bet in C does not fully determine her decision. She must also deduce whether Player 1 will bet in {A,B}. That deduction requires looking at her [2A] payoff. Thus, she must look at all of her own payoffs [2A,2B,2C], as well as [1A,1B] and [S]. Notice also that looking at [2A] means looking at a possible payoff that she knows with certainty will not occur (an impossible counterfactual). This is quite counterintuitive and therefore a clear hallmark of strategic reasoning.

Subjects played a set of 10 games four times for a total of 40 trials in each session. Subjects were randomly re-matched with another subject and randomly assigned to be either Player 1 or Player 2 in each trial. For each trial, the software recorded the final choice as well as the information attended to before making a choice.

## Summary of Results

In our study, the Nash equilibrium was played almost always in trivial games, chosen about half the time in simple games, and played a quarter of the time in complex games. These results demonstrate a high rate of non-equilibrium behavior in both simple and complex games.

The combination of choices and lookup analysis suggest that some subjects looked at the payoffs necessary to make an equilibrium choice, but sometimes these lookups did not translate into making the equilibrium choice. In other cases, they did not look at all the necessary payoffs and did not make equilibrium choices. These patterns reject theory (i) above but are broadly consistent with theories (ii) and (iii).

There was heterogeneity in both lookups and choices. Subjects can be classified into clusters using both measures. In one cluster, subjects usually made an exhaustive analysis of the game, looked at the necessary payoffs and played Nash, but this cluster was small (about 15% of the subjects). Two other clusters looked at the necessary payoffs and usually played Nash in the simple games, but they looked and chose less strategically in the complex games. In a fourth cluster — the most common — subjects spent less total time making choices, looked at necessary payoffs less often, and rarely played Nash. Typically, these subjects played a naïve (or myopic) strategy, consisting of looking exclusively at their own payoffs.

Actual earnings in the four clusters were interesting. Playing Nash was an empirical best response in the simple games but not in complex games. The first cluster did not earn the most money because they looked the most strategically and played Nash often in both types of games, but they acted as if they were overestimating the rationality of their opponents in complex games (which is an earnings mistake). The middle clusters earned the most. The fourth cluster who "under-looked" compared with theory earned the least money.

## CONCLUSION

In interpreting these results, it becomes apparent that they are particularly relevant to understanding the behavior of participants in real estate markets. Typically, players in these markets (buyers, sellers, banks) make risky decisions with imperfect information. Our results suggest that individuals may sometimes take too much risk. They also indicate this attitude may follow from a myopic understanding of the situation. Subjects in the largest cluster four are the paradigmatic example of such an attitude. Actors do not realize other actors have other interests; they tend to trust their own signals, disregarding the fact that others also have signals and act according to what they see as beneficial to them. In other words, they make shortsighted decisions, neglecting relevant information that is either available to them at no cost or can be inferred from a careful analysis of others' incentives. These players are buyers who take prices at face value and do not realize, for instance, that sellers try to make a profit, possibly out of a low value property. Or, these are lenders who do not take into account that buyers will default in the future if the interest rate rises.

This type of research analysis is useful in building new behavioral theories of decision-making, particularly in helping to explain and predict observed micro and macro behaviors. Based on our experience and analysis in this area of research, it is our opinion that real estate markets are in particular need of such models in order to be more predictable and profitable for those involved. Transactions are large, and mistakes are potentially quite costly. As witnessed in recent years, mistakes in judgment also can generate large externalities, or unintended consequences, on the rest of the economy. Moreover, a considerable fraction of the players in real estate are not professionals. They are therefore more inclined to use heuristics and exhibit behavioral biases that in turn increase the probability of mistakes. The benefit of assessing those biases and their causes may help design adequate institutions to protect individuals – and the economy as a whole – against detrimental decision-making.

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