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Rational investor sentiment in a repeated stochastic game with imperfect monitoring

Anke Gerber[a], Thorsten Hens[b,*], Bodo Vogt[c]

[a] *Department of Economics, University of Hamburg, Von-Melle-Park 5, 20146 Hamburg, Germany*
[b] *Swiss Banking Institute, University of Zurich, Plattenstr. 32, 8032 Zurich, Switzerland*
[c] *Otto-von-Guericke University, Department of Economics, Empirical Research in Economics, P.O. Box 41 20, 39016 Magdeburg, Germany*

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ABSTRACT

We consider a repeated stochastic coordination game with imperfect public monitoring. In the game any pattern of coordinated play is a perfect Bayesian Nash equilibrium. Moreover, standard equilibrium selection arguments either have no bite or they select an equilibrium that is not observed in actual plays of the game. We give experimental evidence for a unique equilibrium selection and explain this very robust finding by equilibrium selection based on behavioral arguments, in particular focal point analysis, probability matching and overconfidence. Our results have interesting applications in finance because the observed equilibrium exhibits momentum, reversal and excess volatility. Moreover, the results may help to explain why technical analysis is a commonly observed investment style.

1. Introduction

Ninety percent of what we do is based on perception. It doesn't matter if that perception is right or wrong or real. It only matters that other people in the market believe it. I may know it's crazy, I may think it's wrong. But I lose my shirt by ignoring it.
"Making Book on the Buck"
Wall Street Journal, Sept. 23, 1988, p. 17

Real life abounds with situations where people do best, individually and collectively, by coordinating their actions: communication is only possible if we speak the same language, living together in families, cities or countries is hindered if we do not obey the same rules of conduct, software would be extremely costly to develop if everyone were using a different computer platform, and trading is facilitated if it takes place at common market places or exchanges. A case in which coordination is of particular importance is a financial market. Assuming that investors do not hold assets till maturity, there

* Corresponding author.
E-mail addresses: anke.gerber@wiso.uni-hamburg.de (A. Gerber), thens@isb.unizh.ch (T. Hens), Bodo.Vogt@ww.uni-magdeburg.de (B. Vogt).

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is a natural incentive to buy those assets that other investors would also buy so that one can sell them with capital gains. In all these cases there are several ways in which people could potentially coordinate (rules, norms, technology standards, etc.), so the coordination problem is non-trivial even though there is no conflict of interest. Such problems can be modelled as coordination games, where each player has the same number of strategies and there are multiple, typically Pareto-ranked equilibria. Equilibrium behavior in a coordination game requires that each player correctly anticipates the equilibrium the other players are aiming at, which seems difficult to achieve in a one-shot interaction. By contrast, in repeated interaction it may be possible to learn to coordinate on one equilibrium over time if each player observes the past actions of others. However, in reality an individual often only observes a noisy signal about what others have done in the past, and this may seriously impede the learning process. An investor, for example, can profit in the short-run if she invests according to the average expectation in the market. However, if she only observes asset prices which do not reveal individual trades she may get a very diffuse view of the average expectations of traders in the market.

For these reasons we consider a game where coordination is impeded by the fact that players observe only their own payoffs and these payoffs merely provide a noisy signal about the actions chosen by others. Hence, players can never verify whether coordination has been achieved in the past and therefore cannot simply repeat the successful action in the future. Our game is a simple majority game with a finite number of strategic players who can choose between two actions, u and d. A player receives a positive payoff if her choice matches the majority and a zero payoff otherwise. The majority choice, however, is determined not only by the actions of the strategic players but also by noise, which randomly adds weight to u or d and which can overrule the strategic players with a small probability. Each player observes only the choice of the majority, while the individual actions of the other strategic players and the noise remain hidden. Hence, the game is an example of a stochastic coordination game with imperfect public monitoring (see Abreu et al., 1990). Any pattern of coordinated play is a perfect Bayesian Nash equilibrium of the repeated game, so the problem of equilibrium selection is severe.

Standard dynamic models of learning, adaptive play or evolution[1] have no bite here since all pure strategy equilibria of the stage game are strict and payoff equivalent. To our knowledge the tracing procedure of Harsanyi and Selten (1988) is the only equilibrium selection theory that gives a reasonably narrow (and even unique) prediction for our game. Their procedure selects the inefficient equilibrium with random behavior (in each period all players mix between u and d with equal probability). This equilibrium, however, is not observed in actual plays of the game. Indeed we are able to give robust experimental evidence for a different unique equilibrium selection. In this equilibrium the strategic players simply choose the previous period's outcome as their action. We call this equilibrium the "switch" equilibrium because actual play is coordinated on u or d until the noise overrules the strategic players and everybody switches to the other action. We explain this very robust finding by equilibrium selection based on behavioral arguments, in particular focal point analysis, probability matching and overconfidence.

While a contribution to behavioral equilibrium selection may itself be of interest for game theory, we are interested in this simple game also for its application to financial markets, which we used for the framing of the laboratory experiment. Imagine that, when a player chooses u (d), he initiates an order to buy (sell) one unit of an asset. Then the strategic players may be interpreted as managers of mutual funds, pension funds or hedge funds, while the noise is representing actions exogeneous to the coordination game like the dividends paid by firms or the buying and selling of traders that is not related to rational investing. Indeed the payoff function of our game matches the reward function of those managers. In every period they are assessed in terms of the gains/losses resulting from the actions they have taken in that period. If the manager decides to buy (sell) and prices go up (down) in this period, she will get a positive reward. Otherwise she will get a lower reward. The actual price movement reflected in the majority rule then is a simple version of the law of demand and supply.

Keeping up the analogy to a coordination game, our paper shows that some of the main mechanisms underlying excess volatility, short-term momentum and long-term reversal[2] can be explained as the outcome of a repeated beauty contest with noise. Indeed the "switch" equilibrium has all these features. The volatility (measured in terms of variance) of prices is higher than that of the exogenous noise (given by the die), there are phases in which prices continue in the same direction, and every now and then prices change their direction, reverting to the long-term average. Note that our model explains these upwards and downwards trends of asset markets, commonly called "investor sentiment", as a perfect Bayesian Nash equilibrium. That is to say, we give a rational explanation of investor sentiment. In particular, in contrast to Barberis et al. (1998), the traders in our model have no misperceptions about the statistical distribution of the exogenous random process.

The results of our simple game may help to explain why technical analysis is a commonly observed investment style. In contrast to the efficient market hypothesis put forward by Fama (1970), in the game considered here prices have information content as they are a signal for the achieved coordination in the market. Indeed, in the switch equilibrium the players understand this signal and base their trading on past prices.

Our paper relates to a large theoretical and experimental literature on coordination games. A well-known equilibrium selection theory is the one by Harsanyi and Selten (1988). Their theory is based on two criteria, payoff dominance and risk dominance. If these criteria have opposite implications, then Harsanyi and Selten (1988), as well as Anderlini (1990), favor

[1] For an overview see the books by Weibull (1995), Vega-Redondo (1996), Samuelson (1997), Young (1993), Fudenberg and Levine (1998).

[2] Empirical evidence has shown that stock prices often deviate substantially from their fundamental values and are more volatile than the dividends (Shiller, 1981). Moreover, short-term momentum and long-term reversal of stock market prices are empirically robust stock price anomalies (see, for example, Jegadeesh, 1990; De Bondt and Thaler, 1985; Lo and MacKinlay, 1999; Campbell, 2000; Hirshleifer, 2001).