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Path dependent coordination of expectations in asset pricing experiments: A behavioral explanation

Anna Agliari[a,*], Cars H. Hommes[b,1], Nicolò Pecora[a,2]

[a] Dept. of Economics and Social Science, Catholic University, Piacenza, Italy
[b] CeNDEF, Amsterdam School of Economics, University of Amsterdam and Tinbergen Institute, Netherlands

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ABSTRACT

In the learning-to-forecast laboratory experiments in Hommes et al. (2005), three different types of aggregate asset price behavior have been observed: monotonic convergence to the stable fundamental steady state, dampened price oscillations and permanent price oscillations. We present a simple behavioral 2-type heuristics switching model explaining individual as well as aggregate behavior in the experiment. Based on relative performance, agents switch between a simple trend following and an anchor and adjustment heuristic that differ in how much weight is given to the long run average price level. The nonlinear switching model exhibits path dependence through co-existence of a locally stable fundamental steady state and a stable (quasi-)periodic orbit, created via a so-called *Chenciner* bifurcation. Depending on initial states, agents coordinate individual expectations either on a stable fundamental steady state path or on almost self-fulfilling persistent price fluctuations around the fundamental steady state.

1. Introduction

There are many historical examples of asset or commodity market bubbles, with excessive growth of prices followed by sudden collapse. One of the first and perhaps the most famous is the Dutch “tulipmania” in 1636–1637, when tulip bulbs hit price levels equivalent to several average yearly wage salaries, before they suddenly collapsed in February 1637 (Kindleberger, 2001). More recent examples include the “dot-com” bubble in the high tech NASDAQ stock market with its peak in May 2000 and the housing price bubbles in the U.S. and many other countries between 2000 and 2010. A bubble is defined as a strong and persistent overvaluation of an asset compared to its economic “fundamental value”. Large bubbles and sudden market crashes are hard to reconcile with the standard rational expectations representative agent model, which typically assumes that prices track fundamental value. Popular explanations of the occurrence of bubbles often rely on some

* Corresponding author at: Via Emilia Parmense 84, 29100 Piacenza, Italy. Tel.: +39 0523599191.
E-mail addresses: anna.agliari@unicatt.it (A. Agliari), C.H.Hommes@uva.nl (C.H. Hommes), nicolo.pecora@unicatt.it (N. Pecora).
[1] Roeterstraat 11, NL-1018 WB Amsterdam, Netherlands.
[2] Via Emilia Parmense 84, 29100 Piacenza, Italy.

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form of Greenspan's "irrational exuberance" as an amplification mechanism after (small) fundamental shocks (e.g. Shiller, 2000).

Behavioral finance has documented an increasing list of mechanisms emphasizing the role of investor psychology as an amplification mechanism in explaining large asset price movements, e.g. overconfidence, wishful thinking, gambler's fallacy, momentum trading, trend extrapolation, belief anchoring, availability heuristics, reference dependent utility, loss aversion, ambiguity aversion, etc. (Barberis and Thaler, 2003).

Despite their popularity in the financial press, the existence and empirical relevance of financial bubbles and crashes is still heavily debated among academic economists. The most important reason for the controversy may be that the "fundamental value" of an asset is difficult to measure in real markets and depends e.g. on assumptions about preferences and risk premia. Experiments in a controlled laboratory environment are therefore an important complementary tool to gain insights into possible causes and circumstances that may lead to significant and persistent price deviations from a controlled fundamental value. A seminal contribution are the bubble experiments in Smith et al. (1988). Subjects can buy an asset that pays a dividend 1 each period. The market lasts 15 periods, so that fundamental value is a decreasing step function from 15 to 0. Experimental markets typically do not track the fundamental, however, but rather start below fundamental with a price around 4–5, after which the price starts to increase, then becomes overvalued reaching a maximum up to 15 or more around period 10, and finally collapses to 0 towards the end of the experiment. There is a large literature showing that these experimental asset market bubble and crashes are robust w.r.t. many variations in the experimental design (see Palan, 2013 for an extensive survey).[3]

To study the role of expectations in generating bubbles and crashes, Hommes et al. (2005) ran so-called learning-to-forecast asset pricing experiments with a constant fundamental value and computerized optimal trading. Subjects play the role of professional forecasters and are asked to submit point forecasts for the price of a risky asset for 50 periods. The risky asset pays an uncertain dividend in each period. Individual forecasts feed into a standard mean-variance demand function and the price of the risky asset, p_t, is determined every period by market clearing, as an aggregation of individual forecasts of all participants. An important feature of these experimental asset markets is the *positive feedback*, that is, the higher the individual forecasts, the larger the demand for the risky asset and the higher the realized market price. The fundamental price of the risky asset is not explicitly given to the subjects, but can be computed as the discounted sum of expected future dividends from common knowledge of the mean dividend $\bar{y}$ and the risk-free interest rate r. In the experiment, the fundamental price becomes $p^f = \bar{y}/r = 60$.

In 20 experimental markets, three different patterns of aggregate behavior have been observed (Fig. 1a–c): (i) slow and almost monotonic convergence to the fundamental price, (ii) persistent oscillations around the fundamental value and (iii) dampened price oscillations. Moreover, participants are able to *coordinate* on a common *almost self-fulfilling* forecasting strategy, but this strategy can be different between groups. The analysis of individual prediction strategies in Hommes et al. (2005) reveals that the dispersion between prediction strategies is much smaller than the forecast errors participants make on average. This indicates that participants within a group coordinate on a common prediction strategy. Although participants make forecasting errors, they are similar in the way that they make these errors. Estimation of the individual prediction strategies shows that participants tend to use simple linear prediction strategies, such as naive expectations, adaptive expectations or "autoregressive" expectations. Again, participants within a group coordinate on using the same type of simple prediction strategy. These prediction strategies make relatively small errors and are in this sense almost self-fulfilling. Almost self-fulfilling equilibria are a key feature of *positive feedback* systems, in particular when they are near-unit root systems (see Hommes (2013a) for a discussion). Since the discount factor $1/(1+r)$ is very close to 1, the price generating mechanism of the asset pricing experiment (see Eq. (1)) follows a near-unit root process. If the system would have a unit root, a continuum of rational expectations steady states would exist. Since the system is near unit root, it has a continuum of almost self-fulfilling equilibria. What the lab experiments in Hommes et al. (2005) then have shown is that agents may coordinate on an oscillatory pattern or sequence of almost self-fulfilling equilibria.

The purpose of this paper is to develop a simple 2-type behavioral heuristics switching model which is able to explain the path-dependent coordination of individual expectations on these different observed aggregate outcomes. Agents are boundedly rational and switch between two simple forecasting heuristics based on their relative performance. Strategy switching is thus based on an evolutionary selection mechanism. The two forecasting heuristics are a simple trend-following rule and an anchor and adjustment heuristic. Both rules extrapolate the latest observed price trend, but differ in their anchor describing how much weight is given to the last price observation and to the long run average price level. The nonlinear switching model exhibits *path dependence* through *co-existence* of a locally stable fundamental steady state and a stable (quasi-)periodic orbit. Depending on initial states, agents coordinate individual expectations either on a locally stable fundamental steady state path or on persistent (quasi-)periodic price fluctuations around the fundamental steady state. The fundamental steady state is the homogeneous rational expectations outcome, while the persistent fluctuations around the

[3] Kirchler et al. (2012) and Huber and Kirchler (2012) show however that the bubbles disappear when a more accurate framing of the fundamental value is used by describing it as the depletion of a gold mine rather than a stock market. Dufwenberg (2014) studied repeated bubble experiments with experienced and inexperienced traders and show that bubbles disappear when (part of) the subjects become more experienced. These results show that bubbles in experimental markets are still not fully understood and more experiments are needed to shed light on the circumstances in which bubbles may or may not prevail.