Journal of Economic Behavior & Organization 92 (2013) 304–316

Contents lists available at ScienceDirect

Journal of Economic Behavior & Organization

journal homepage: www.elsevier.com/locate/jebo

Super-exponential bubbles in lab experiments: Evidence for anchoring over-optimistic expectations on price

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ARTICLE INFO

Article history:
Received 3 May 2012
Received in revised form 5 June 2013
Accepted 14 June 2013
Available online 25 June 2013

JEL classification:
C92
D84
G12

Keywords:
Anchoring
Financial bubbles
Laboratory experiments
Speculation
Super-exponential growth
Positive feedback

ABSTRACT

We analyze a controlled price formation experiment in the laboratory that shows evidence for bubbles. We calibrate two models that demonstrate with high statistical significance that these laboratory bubbles have a tendency to grow faster than exponential due to positive feedback. We show that the positive feedback operates by traders continuously upgrading their over-optimistic expectations of future returns based on past prices rather than on realized returns.

1. Introduction

Bubbles, defined as significant persistent deviations from fundamental value, express one of the most paradoxical behaviors of real financial markets. Here, we analyze the dynamics of bubbles in a laboratory market (Hommes et al., 2008) and focus on the regimes of strong deviations from the fundamental values, which we refer to as the bubble regimes. Because this data is from a controlled environment, we can exclude exogenous influences such as news or private information. We show that a model with exponential growth, corresponding to a constant rate of returns, cannot account for the observed transient explosive price increases. Models that incorporate positive feedback leading to faster-than-exponential growth are found to better describe the data.

Research on financial bubbles has a rich literature (see e.g. Kaizoji and Sornette, 2010 for a recent review) aiming at explaining the origin of bubbles, their persistence and other properties. The theoretical literature has classified different types of bubbles following different modeling approaches. For instance, Blanchard (1979) and Blanchard and Watson (1982) introduced rational expectation (RE) bubbles, i.e., bubbles that appear in the presence of rational investors who are willing to earn the large returns offered during the duration of the bubble as a remuneration for the risk that the bubble ends in

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0167-2681/$ – see front matter
http://dx.doi.org/10.1016/j.jebo.2013.06.005

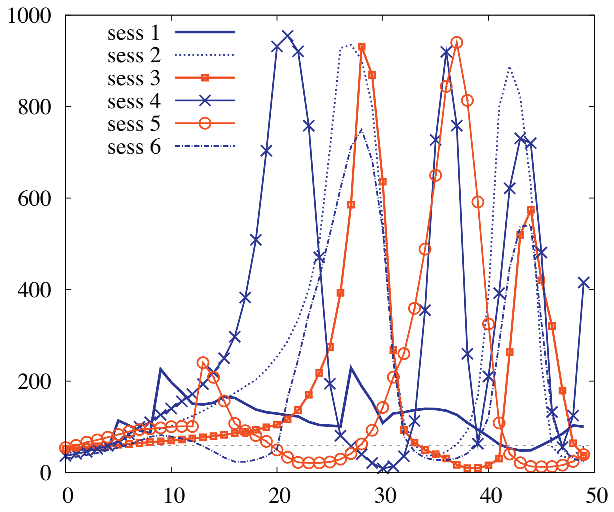

Fig. 1. Prices in the learning-to-forecast market experiments (Hommes et al., 2008). 5 out of 6 markets exhibit long lasting bubbles with asset prices increasing to more than 15 times fundamental value.

a crash. Tirole (1982) argued that heterogeneous beliefs among traders are necessary for bubbles to develop. DeLong et al. (1990b) demonstrated that introducing noise traders in a universe of rational speculators can amplify the size and duration of bubbles. Brock and Hommes (1998) showed that endogenous switching between heterogeneous expectations rules, driven by their recent relative performance, generates bubble and crash dynamics of asset prices. Gallegati et al. (2011) presented an agent-based model of bubbles and crashes, where crashes occur after a period of financial distress. A recent review of behavioral models of bubbles and crashes with fundamentalists trading against chartists is given in Hommes (2006).

There is also a large literature on empirical tests for bubbles, see e.g. Gürkaynak (2008) for a survey. Lux and Sornette (2002) showed that the multiplicative stochastic process proposed by Blanchard and Watson (1982), together with the no-arbitrage condition, predicts a tail exponent of the distribution of returns smaller than 1, which is incompatible with empirical observations. Johansen et al. (1999) and Johansen et al. (2000) thus extended the Blanchard and Watson (1982) model of RE bubbles by proposing models in which the crash hazard rate reflects the imitation and herding behavior of the noise traders and exhibits critical bifurcation points. In these models asset bubbles are characterized by faster-than-exponential growth and this behavior has been found in many financial time series, e.g. the Chinese stock market (Jiang et al., 2010), oil prices (Sornette et al., 2009), the NASDAQ-index and the dot.com bubble (Johansen and Sornette, 2000) and the U.S. housing market (Zhou and Sornette, 2006). A common feature of asset bubbles with faster-than-exponential growth is that prices seem to be only loosely connected to fundamentals, leaving much room for excessive speculating and rapidly growing asset prices (see e.g. Kindleberger (1978) for qualitative examples and Sornette (2004) for a more extensive discussion). Another recent bubble example that seems to exhibit faster-than-exponential growth is the Bitcoin bubble and crash in April 2013. Bitcoins are a product of the virtual economy, intended to allow Internet peer-to-peer transactions without the need for banking intermediaries. Bitcoins have no intrinsic fundamental value. Within a couple of months, the exchange rate for a single Bitcoin quickly rose this year by a factor of 13(!) from 20 dollars in January 2013 to an intraday high of $266 on April 10, before falling to $186 later that same day and back to $54 three days later.

Laboratory experiments with human subjects are well suited to study the emergence of bubbles in a controlled environment. Following the seminal work of Smith et al. (1988), a large literature on bubbles in laboratory experimental markets has emerged. Smith et al. (1988) showed how easily bubbles can emerge in experimental markets, even with experienced traders. Since then, numerous papers have studied the robustness of bubbles in experimental asset markets. For example, Haruvy and Noussair (2006) impose short selling constraints, while Lei et al. (2001) preclude speculation by prohibiting buyers to resell the asset and sellers to buy, but in both cases asset bubbles are robust features. In these laboratory experiments, the fundamental value of the asset is decreasing over time (typically decreasing from 15 to 0 over 15 time periods). Prices then start below fundamental, after a few periods cross and overshoot fundamental value leading to high overvaluation of the asset and finally a crash occurs towards the end of the experiment. Kirchler et al. (2012) have recently shown that the declining fundamental value coupled with an increasing cash-to-asset-value ratio is an important drivers of the mispricing and overvaluation. They also show that, with a different context (“stocks of a depletable gold mine” instead of “stocks”), mispricing and overvaluation are reduced.

The Smith et al. laboratory experiments are too short (only 15 periods) to perform statistical testing for super-exponential bubbles. Longer asset market experiments, for 50 periods, have been performed in Hommes et al. (2005). In these learning-to-forecast experiments, subjects are professional forecasters of the price of a risky asset, with the realized price depending upon average price forecasts. In their setup, one of the computerized traders is a fundamental robot trader, following a forecasting/trading strategy based upon the correct (constant) fundamental price, while the other trading decisions are