Journal of Economic Behavior & Organization 112 (2015) 289–310

Contents lists available at ScienceDirect

Journal of Economic Behavior & Organization

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

Super-exponential endogenous bubbles in an equilibrium model of fundamentalist and chartist traders

Taisei Kaizoji[a,1], Matthias Leiss[b,*,1], Alexander Saichev[b,c,2], Didier Sornette[b,d]

[a] Graduate School of Arts and Sciences, International Christian University, 3-10-2 Osawa, Mitaka, Tokyo 181-8585, Japan
[b] ETH Zurich, Department of Management, Technology and Economics, Kreuzplatz 5, CH-8032 Zurich, Switzerland
[c] Nizhni Novgorod State University, Department of Mathematics, Russia
[d] Swiss Finance Institute, c/o University of Geneva, 40 Boulevard Du Pont d'Arve, CH 1211 Geneva 4, Switzerland

ARTICLE INFO

Article history:
Received 16 January 2014
Received in revised form 25 November 2014
Accepted 1 February 2015
Available online 13 February 2015

JEL classification:
C73
G01
G17

Keywords:
Financial bubbles
Faster-than-exponential growth
Social imitation
Momentum trading
Chartists
Dotcom bubble

ABSTRACT

We introduce a model of super-exponential financial bubbles with two assets (risky and risk-free), in which fundamentalist and chartist traders co-exist. Fundamentalists form expectations on the return and risk of a risky asset and maximize their constant relative risk aversion expected utility with respect to their allocation on the risky asset versus the risk-free asset. Chartists are subjected to social imitation and follow momentum trading. Allowing for random time-varying herding propensity, we are able to reproduce several well-known stylized facts of financial markets such as a fat-tail distribution of returns and volatility clustering. In particular, we observe transient faster-than-exponential bubble growth with approximate log-periodic behavior and give analytical arguments why this follows from our framework. The model accounts well for the behavior of traders and for the price dynamics that developed during the dotcom bubble in 1995–2000. Momentum strategies are shown to be transiently profitable, supporting these strategies as enhancing herding behavior.

1. Introduction

The very existence of financial bubbles has been a controversial and elusive subject. Some have argued that financial bubbles play a huge role in the global economy, affecting hundreds of millions of people (Kindleberger, 1978; Shiller, 2000; Sornette, 2003). Others have basically ignored or refuted their possibility (Fama, 1998). Moreover, until recently, the existence of such bubbles, much less their effects, have been ignored at the policy level. Finally, only after the most recent historical global financial crisis, officials at the highest level of government and academic finance have acknowledged the existence and importance of identifying and understanding bubbles. The President of the Federal Reserve Bank of New York, William C. Dudley, stated in April 2010 "what I am proposing is that we try–try to identify bubbles in real time, try to develop tools to address those bubbles, try to use those tools when appropriate to limit the size of those bubbles and, therefore, try to limit

* Corresponding author. Tel.: +41 446328708.
E-mail addresses: kaizoji@icu.ac.jp (T. Kaizoji), mleiss@ethz.ch (M. Leiss), dsornette@ethz.ch (D. Sornette).
[1] Joint first authors.
[2] Deceased 8 June 2013.

http://dx.doi.org/10.1016/j.jebo.2015.02.001
0167-2681/

the damage when those bubbles burst." Such a statement from the New York Fed representing, essentially, the monetary policy of the United States governmental banking system would have been, and, in some circles, still is, unheard of. This, in short, is a bombshell and a wake-up call to academics and practitioners. Dudley exhorts to try to develop tools to address bubbles.

But before acting against bubbles, before even making progress in ex-ante diagnosing bubbles, one needs to define what is a bubble. The problem is that the "econometric detection of asset price bubbles cannot be achieved with a satisfactory degree of certainty. For each paper that finds evidence of bubbles, there is another one that fits the data equally well without allowing for a bubble. We are still unable to distinguish bubbles from time-varying or regime-switching fundamentals, while many small sample econometrics problems of bubble tests remain unresolved." summarizes Gurkaynak (2008) in his review paper.

Let us start with the rather generally accepted stylized fact that, in a period where a bubble is present, the stock return exhibits transient excess return above the long-term historical average, giving rise to what could be termed a "bubble risk premium puzzle". For instance, as we report in the empirical section, the valuation of the Internet stock index went from a reference value 100 in January 1998 to a peak of 1400.06 in March 9, 2000, corresponding to an annualized return of more than 350% ! A year and a half later, the Internet stock valuation was back at its pre-1998 level. Such explosive super-exponential growth has been documented extensively for bubbles in real markets (see for example Sornette et al., 2009; Jiang et al., 2010; Yan et al., 2012) and recently observed in lab experiments (Hüsler et al., 2013). Another stylized fact well represented during the dotcom bubble is the highly intermittent or punctuated growth of the stock prices, with super-exponential accelerations followed by transient corrections, themselves followed by further vigorous rebounds (Johansen and Sornette, 2010; Sornette and Woodard, 2010).

Bubbles are usually followed by crashes, in an often tautological logic resulting from the fact that the existence of a crash is usually taken as the ex-post signature of a bubble, as summarized by Greenspan (2002): "We, at the Federal Reserve… recognized that, despite our suspicions, it was very difficult to definitively identify a bubble until after the fact, that is, when its bursting confirmed its existence…." More optimistically but still controversial, recent systematic econometric studies have shown that it is possible to relate objectively an anomalous transient excess return and the subsequent crash (Sornette, 2003; Johansen and Sornette, 2010). Furthermore, there is another relatively new stream of literature devoted to the early detection of bubbles, which also focuses on the often observed extreme growth of the price mentioned above. Phillips et al. (2011) have employed mildly explosive autoregressive processes of the log-price with an AR coefficient slightly larger than one decreasing toward one over time. This model results in super-exponential growth of the price and has led to bubble tests based on Markov-switching state-space models (Al-Anaswah and Wilfling, 2011; Lammerding et al., 2013), as well as sequential Chow-type and augmented Dickey–Fuller testing procedures for a structural breaks. Such a break could be either the start of a bubble, i.e. a transition from a random walk to a mildly explosive regime (Phillips et al., 2011; Phillips et al., 2013a; Homm and Breitung, 2012) or vice versa its end (Breitung and Kruse, 2013; Breitung, 2014). Both methods rely on the type of indirect stationarity tests initiated by Diba and Grossman (1988) and Hamilton and Whiteman (1985).

Going from econometrics to financial economics, there are several branches dedicated to modeling deviations from fundamental value. One important class of theories is related to *noise traders* (also referred to as positive-feedback investors), a term first introduced by Kyle (1985) and Black (1986) to describe irrational investors. Thereafter, many scholars exploited this concept to extend the standard models by introducing the simplest possible heterogeneity in terms of two interacting populations of rational and noise traders. One can say that the one-representative-agent theory is being progressively replaced by a two-representative-agents theory, analogously to the progress from the one-body to the two-body problems in physics. It has been often explained that markets bubble and crash in the absence of significant shifts in economic fundamentals when herders such as chartists deliberately act against their private information and follow the crowd.

De Long et al. (1990a,b) proposed the first model of market bubbles and crashes which exploits this idea of the possible role of noise traders following positive feedback or momentum investment strategies in the development of bubbles. They showed a possible mechanism for why asset prices may deviate from the fundamentals over long time periods. The key point is that trading between rational arbitrageurs and chartists gives rise to bubble-like price patterns. In their model, rational speculators destabilize prices because their trading triggers positive feedback trading by noise traders. This in turn leads to a positive auto-correlation of returns at short horizons. Eventually, arbitrage by rational speculators will pull the prices back to fundamentals. Their arbitrage trading leads to a negative autocorrelation of returns at longer horizons.

Their work was followed by a number of empirical studies on positive feedback trading. Influential empirical evidence on positive feedback trading came from the works of De Bondt and Thaler (1985), and Jegadeesh and Titman (1993, 2001), which established that stock returns exhibit momentum behavior at intermediate horizons, and reversals at long horizons. That is, strategies which buy stocks that have performed well in the past and sell stocks that have performed poorly in the past generate significant positive returns over 3- to 12-month holding periods. However, stocks that perform poorly in the past perform better over the next 3–5 years than stocks that perform well in the past. Behavioral models that explain the coexistence of intermediate horizon momentum and long horizon reversals in stock returns are proposed by Barberis et al. (1998), Daniel et al. (1998), and Hong and Stein (1999).

The behavior of investors who are driven by group psychology and the aggregate behavioral outcomes, have also been studied using frameworks suggested by Weidlich and Haag (1983), Blume (1993, 1995), Brock (1993), Durlauf (1997, 1999), Kirman (1993), Brock and Durlauf (2001), Aoki and Yoshikawa (2007), Chiarella et al. (2009) and Hommes and Wagener