Journal of Economic Dynamics & Control 80 (2017) 101–124

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

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

Booms, busts and behavioural heterogeneity in stock prices☆

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ARTICLE INFO

Article history:
Received 24 September 2016
Revised 5 April 2017
Accepted 7 May 2017
Available online 12 May 2017

JEL Classification:
G12
C22
G01

Keywords:
Behavioural finance
Bounded rationality
Heterogeneous expectations
Stock prices
Financial crisis

ABSTRACT

We estimate a behavioural heterogeneous agents model with boundedly rational traders who know the fundamental stock price, but disagree about the persistence of deviations from the fundamental. Some agents (fundamentalists) believe in mean-reversion of stock prices, while others (chartists) expect a continuation of the trend. Agents gradually switch between the two rules, based upon their relative performance, leading to self-reinforcing regimes of mean-reversion and trend-following. For the fundamental benchmark price we use two well-known models, the Gordon model with a constant risk premium and the Campbell-Cochrane consumption-habit model with a time-varying risk premium. We estimate a two-type switching model using U.S. stock prices until 2016Q4. The estimations show an improvement over representative agent models that is both statistically and economically significant. Our model suggests that behavioural regime switching strongly amplifies booms and busts, in particular, the dot-com bubble and the financial crisis in 2008.

1. Introduction

Economic reality shows the limitations of standard asset pricing models with a representative rational agent only concerned with economic fundamentals. In 2008 the S&P500 stock index, the financial bellwether of the economy of the U.S., and many other stock indices, lost around one half of their total value. While the bankruptcy of Lehman Brothers amounted to a clear fundamental shock to the economy, it is hard to believe that all of these losses amounted to a rational re-evaluation of fundamentals. Other explanations, in which behaviour leads to excess volatility, need to be considered. In this paper we present evidence from S&P500 data that market sentiment switches between different behavioural regimes, which amplified shocks such as the Lehman bankruptcy, and more generally amplifies booms and busts of the economy.

☆ The authors would like to thank Robert Shiller and Sydney Ludvigson for sharing data via their websites, and Cees Diks and Marco van der Leij for sharing programming code and helpful discussions. We are grateful to Jules van Binsbergen, Peter Boswijk, William Branch, Peter Broer (discussant), Lennart Dek, George Evans, Petri Jylha (discussant), Bochen Li (discussant), Sebastiano Manzan, Simon van Norden, Remco Zwinkels and three anonymous referees for useful comments. We also thank participants at the Computing in Economics and Finance conference CEF2012 (Prague), the INEXC conference 2013 "Expectational Coordination and the Stock Market" (Paris), the Midwest Finance Association Annual Conference 2014 (Orlando), the Research in Behavioural Finance Conference 2014 (Rotterdam), the European Finance Association conference EFA 2015 (Vienna) and seminars at the University of Amsterdam, Tinbergen Institute, UC Irvine, the University of Oregon, the University of Pisa, the CPB Netherlands Bureau for Economic Policy Analysis, and SEO Amsterdam Economics. The research has been supported by the Netherlands Organisation for Scientific Research (NWO) under the Complexity program *Understanding financial instability through complex systems*.

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http://dx.doi.org/10.1016/j.jedc.2017.05.006
0165-1889/

We first apply the idea of switching market sentiment to a basic framework that provides a fundamental value of the price-dividend ratio: the standard Gordon solution based on a constant risk premium. Within this framework we introduce a simple behavioural model with some agents believing in mean-reversion of stock prices (called fundamentalists) and others (called chartists) who expect a continuation of the trend. Agents gradually switch between the two rules, based upon their relative performance, so they learn and adapt their behaviour if the market situation changes and the losses of their strategy become too large. Because of the positive expectations feedback in asset markets, self-reinforcing behavioural regimes of mean-reversion and trend-following arise endogenously in the model, explaining large and persistent deviations of the S&P500 from the Gordon fundamental value.

A convenient feature of our model is that it is formulated in deviations from a fundamental price, so that it can be tested against any suitable fundamental benchmark. Behavioural heterogeneity can therefore complement the mainstream financial literature on stock market fluctuations by providing an *amplification mechanism* to explain excess volatility (Shiller, 1981). To this end we combine our model with the consumption-habit asset pricing model of Campbell and Cochrane (1999). They argue in a standard representative-agent framework that booms and busts in asset prices are driven by countercyclical variation in risk premia, which in turn are inversely related to consumption relative to a slow-moving habit level. We show that even if part of the variation in the price-dividend ratio can be explained by consumption-driven variation in risk premia, our model still gives significant parameter estimates and adds explanatory power due to behavioural heterogeneity. Overall, we argue that there is strong evidence for heterogeneous beliefs amplifying booms and busts in the stock market.

Standard asset pricing models do not take heterogeneity into account as these models assume the expectations of individual investors are rational and can be described by a representative agent. Asset prices should in this view equal the *fundamental value* of expected discounted sum of future cashflows, or more specifically dividend payoffs (Campbell and Shiller, 1988a). Various reasons have been proposed why this fundamental value could change over time, as in Campbell and Cochrane (1999). Bansal and Yaron (2004) argue for the effects of long-run economic uncertainty on asset prices. Pástor and Veronesi (2006) and Ofek and Richardson (2003) give particular (but very different) explanations for the high valuations of technology firms in the late 1990s. Nevertheless, these explanations may not be sufficient to fully explain stock market fluctuations. More specifically, we show that for the consumption-habit model of Campbell and Cochrane (1999), behavioural heterogeneity is a significant amplification mechanism.

With the contention that the financial crisis cannot be sufficiently explained by economic fundamentals, our paper fits within the *behavioural* finance literature. Departing from the strongest form of rationality opens up the alternative view that stock prices may have been overpriced. The behavioural finance literature is surveyed in e.g. Hirshleifer (2001) and Barberis and Thaler (2003). Barberis and Thaler (2003) stress the finding that traders with flawed expectations can not always be driven away from the market. As these traders distort supply and demand based on fundamentals, assets can be partly mispriced. In their words: "One of the biggest successes of behavioral finance is a series of theoretical papers showing that in an economy where rational and irrational traders interact, irrationality *can* have a substantial and long-lived impact on prices." (Barberis and Thaler, 2003, p. 1053, their emphasis).

Barberis and Thaler (2003) also state that careful empirical analysis remains the main challenge for behavioural models. As one recent example, Branch and Evans (2010) develop a framework with agents learning the parameters of their under-parameterised forecasting models and reproduce regime-switching returns and volatilities in monthly U.S. stock data. Adam and Marcet (2011) and Adam et al. (2013) provide another example where investors' subjective beliefs are shown to drive booms and busts in the S&P500's price-dividend ratio. In these examples however the model is calibrated to replicate certain characteristics in the data. Moreover, these models assume learning by a homogeneous representative agent: see Pástor and Veronesi (2009) for a stimulating survey. Our simple behavioural model assumes heterogeneous agents and contains few parameters that can be estimated directly.

We will model our boundedly rational traders within the *heterogeneous agents* asset pricing framework of Brock and Hommes (1997, 1998).[1] The literature on Heterogeneous Agents Models (HAMs) has been growing in the last decades and is extensively reviewed in e.g. Hommes (2006), LeBaron (2006) and Lux (2009). For example, HAMs have been applied to stock prices empirically in Boswijk et al. (2007), Franke and Westerhoff (2012), Chiarella et al. (2014) and Lof (2012, 2015). Switching models with heterogeneous agents have also been applied to other financial markets, in particular exchange rates (Kirman and Teyssière, 2002; Westerhoff and Reitz, 2003; Alfarano et al., 2005; De Grauwe and Grimaldi, 2006; de Jong et al., 2010), but also for example to option prices (Frijns et al., 2010), oil prices (ter Ellen and Zwinkels, 2010) and CDS prices (Chiarella et al., 2015). This empirical literature is growing fast, see e.g. Chen et al. (2012) for an overview.

Our paper makes four contributions to the empirical literature on behavioural asset pricing. Most importantly, we generalise the asset pricing model with heterogenous agents and test it against two benchmark fundamentals, the Gordon model and the Campbell-Cochrane consumption-habit model. A second novelty in the literature is that we introduce agents' memory of earlier realised excess returns. This will lead to gradual (rather than instant) switching and makes the model applicable to quarterly data with a simple economic interpretation. A third, methodological contribution is to run Monte Carlo simulations to clarify two difficulties in estimating HAMs: the stationarity of the time series and the significance of the switching intensity. Finally, we look in greater detail at the price dynamics in the recent turbulent years in terms of

[1] Other related early heterogeneous agents models include the noise trader models of DeLong et al. (1990a, 1990b), the model with 'newswatchers' versus momentum traders of Hong and Stein (1999) and the model of a pure-exchange economy with Bayesian learners by Cogley and Sargent (2009). These models also assume bounded rationality of (at least one type of) agents, but do not allow for switching between different strategies.