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BUBBLE IDENTIFICATION AND CRASH PREDICTION IN HOUSING MARKETS WITH THE LPPL MODEL

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MOTIVATION

Asset price bubbles lead to misallocation of resources and to shocks on the economy when they burst, as revealed by the current financial crisis triggered by the US-housing bubble. In order to successfully conduct countermeasures against bubbles, it is crucial for monetary and fiscal policies to be able to identify bubbles at an early stage. Current literature on bubble identification is based on the idea of testing the null hypothesis of the non-existence of a bubble against some estimation of fundamental prices (Gürkaynak, 2008). The difficulties of these tests lie in the estimation of fundamental asset prices. The specific properties of the asset housing hamper the identification of price bubbles in these markets even more.

The Log Periodic Power Law Model (LPPL) overcomes theses caveats by describing the stochastic path of a bubble instead of estimating fundamental prices. The LPPL Model has been developed independently by physics Sornette and Johanson (1998) as well as Feigenbaum (2001) in order to predict endogenous crashes in stock markets. In this paper I will apply the LPPL Model to the US housing market and test its power to identify bubbles and to predict crashes in housing markets on historical data.

THE MODEL

The macro-economic foundation of the model lies in the seminal work of Blanchard (1979) and Blanchard and Watson (1982). They showed the existence of a bubble to be possible within the framework of rational expectations. As a consequence of the no-arbitrage condition and rational behaviour, a bubble can only exist, when its bursting is not a deterministic outcome, i.e. if there is a non-zero chance for the bubble not to burst but only to deflate slowly over time. Elsewise, backwards induction would hinder the evolution of bubbles from the beginning on. This is reflected in the price equation for rational endogenous bubbles (Blanchard and Watson, 1982):

$$p(t) = p^f(t) + c(t),$$

where $p(t)$ is the actual observable price, $p^f(t)$ is the fundamental price and $c(t)$ is the bubble component in the regime of an rational endogenous bubble. $c(t)$ is not deterministic, but follows a stochastic path. Endogenous rational bubbles show similarities in the way they

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evolve and grow. The crash, i.e. the burst of a bubble, is a stochastic event with a probability below one. Under rational expectations, the bubble term evolves proportional to the probability of a crash. Intuitively, rational agents must be compensated by higher returns as the risk of a crash rises in order to stay in the market. Under the law of one price and under rational expectations, the price evolves proportional to the hazard rate of a crash within a bubble regime. The hazard rate gives the probability of the occurrence of a crash under the condition that it has not occurred yet.

On a micro-level the hazard rate of the crash can be modelled by means of statistical physics (Johansen, Ledoit and Sornette, 2000). The concepts of herding behaviour, (un)willing cooperation, imitation and positive feedback that underlay the model of the hazard rate stem from financial behaviour (Shleifer and Vishny, 1997, Shiller, 2005). All market participants are organized in networks of family, friends and colleagues. Agents influence each other from one period to another in their investment decision. The decision of one agent to buy or sell (+ or -) depends on the behaviour of the agents within her network and an idiosyncratic signal she alone receives:

$$s_i(t+1) = sign\left(K_i \sum_{j=1}^{n} s_j + \sigma_i \varepsilon_i\right)$$

Where $s_i(t+1)$ is the decision of an agent whether to buy, hold or sell within the next period described as a signum function. K_i is the coupling strength between traders of a network and can be heterogeneous across pairs of neighbors. N is the set of traders who influence trader i. S_j is the current state of trader j. σ_i Is the tendency towards idiosyncratic behavior of an agent. $\varepsilon_i \sim N(0,1)$ is an individually received signal. The purpose of this equation is to formalize the decision process of an individual trader. In non-bubble regimes disorder rules, i.e. agents disagree on whether to buy or sell. Prices lead to market clearance by matching demand and supply. But when the average K_i rises, order appears in the market. It becomes more and more likely that many market participants make the same decision, e.g. they sell and thus trigger a fire sale. An endogenous crash is the outcome of the fight between order (K_i) and disorder (σ_i). The hazard rate of an endogenous crash depends on the evolution of the imitation strength over time (K_i). The evolution of K_i itself depends on the market structure.

The market structure refers to the fact that some market participants have more direct neighbors in their network and that they have stronger influences on other neighbors. Large hedge funds and big investors have more influence on the market than small investors. Statistical physics provides the necessary concepts of scale invariances and fractal dimensions needed to formalize the hierarchical structure of markets and to describe the corresponding hazard rate for endogenous crashes. Since the hierarchical structure in housing markets differs from that in stock markets, I modify the LPPL Model in this paper accordingly. I also modify the LPPL model for the housing markets in order to account for the short sale constraint in these markets.

Plugging the equations for the hazard rate into the equation for price evolvement under rational endogenous bubble regimes gives the LPPL Model:

$$p(t) = A + B(t_c - t)^z + C(t_c - t)^z \cos[\omega log(t_c - t) + \Phi] ,$$

where $p(t)$ is the observable price, t the time and t_c the most probable point in time for a crash. A, B and C are linear parameters. Z is the growth exponent, ω the amplitude of the log periodic swings and Φ the phase constant. The LPPL model, as stated above, captures the similar movements that rational endogenous bubbles have in common. The most probable time of a crash is given by parameter t_c in the equation. By fitting the Log-Periodic Power Law equation to a time series, it is possible to identify a rational endogenous bubble and to predict the event of its crash.

RESULTS

I will apply the modified version of the LPPL model to the S&P/Case-Shiller Home Price Indices for 19 MSA's in the USA over the last 24 years. The model should only fit to times of bubble regimes and should make crash predictions within a reasonable time span. Preliminary findings are very promising. Fitting the model to the S&P/Case-Shiller Home Price Index for Los Angeles up to End of 2004, leads to an adjusted R^2 of over 99 % , strongly indicating the existence of a bubble already at the end of 2004. With data until the end of 2004 the model predicts the most probable time of the crash (t_c) for January 2006. The actual burst took place nine months later. Assured by this promising result, I will comprehensively test the model on housing data for the US, to show that detecting housing bubbles in time is possible. And if it was possible, fiscal and monetary politics could be implemented to prevent future financial crises triggered by bubbles in housing market.

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