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Can a stochastic cusp catastrophe model explain housing market crashes?

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A R T I C L E I N F O

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A B S T R A C T

Like stock market prices, housing prices often exhibit temporary booms and busts. A possible explanation for the observed abrupt changes is offered by the stochastic catastrophe model. This paper addresses the question whether the catastrophe model can describe and predict the dynamics of housing markets. We fit a stochastic cusp catastrophe model to empirical housing market data for six OECD countries, US, JP, UK, NL, SE and BE. Two different estimation approaches are considered – Cobb's method and Euler discretization. The analysis shows that while Cobb's approach describes the long-run stationary density better, Euler discretization is more tailored for time series, as it provides better one-step-ahead predictions. Proceeding using the Euler discretization method we discuss the dynamics of housing markets in terms of the multiple equilibria cusp catastrophe model. By considering the long-term interest rate as an exogenous variable we obtain new insights into the policy implications of interest rate levels, in particular concerning the stability of housing markets.

1. Introduction

The collapse of the U.S. housing bubble in 2007 was followed by a worldwide financial crisis. This tragedy has raised great concerns of housing bubbles among financial regulators and researchers. Like stock market bubbles, housing bubbles in hindsight often can be identified with unjustified increases in housing prices before they crash. Fig. 1 illustrates the bust phase of housing price cycles surrounding banking crises from 1899 to 2008 using real housing prices (Reinhart and Rogoff, 2009). The historical average of the declines from peak to trough is 35.5 percent. A number of countries with major housing crashes are included. For instance, Finland, Colombia, the Philippines and Hong Kong have experienced the most severe real housing prices crashes in the past 25 years. The severity of these crashes amounted to 50–60 percent from peak to trough. Notably, these housing price declines have been quite long lived, averaging roughly 6 years. After the housing market crash of Japan in 1992, real housing prices declined for a consecutive 17 year period. In particular, housing price declines are even longer lived than equity price declines. The average historical downturn phase in equity prices lasts 3.4 years, about half of the downturn phase in housing prices (Reinhart and Rogoff, 2009). The International Monetary Fund (IMF) recorded that housing price busts lasted nearly twice as long and led to output losses that are twice as large as for asset price busts (IMF World Economic Outlook, 2003). Moreover, financial crises and recessions are often preceded by housing market crashes (Reinhart and Rogoff, 2009). The credit crisis and the global financial crisis in 2008 are convincing examples. After housing

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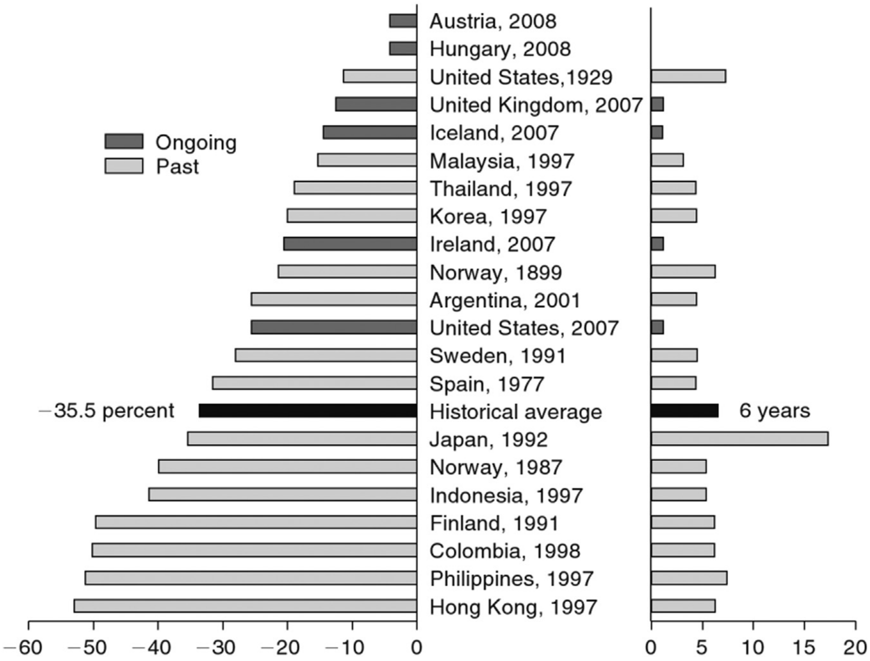

Fig. 1. The bust phase of housing price cycles surrounding banking crises. Left panel: peak-to-trough price declines; Right panel: years duration of downturn. [Reproduced with publisher's permission from Reinhart and Rogoff (2009).]

prices declined in the latter half of 2007, the secondary mortgage market collapsed. A complex chain reaction almost brought down the worldwide financial system. Furthermore, housing market bubbles are considered as leading indicators of financial instability and crises (Davis and Heathcote, 2005). For the above reasons, a good understanding of the instability in housing markets is crucial.

Housing market models have been studied extensively in the literature. Unfortunately, most of the available research in macroeconomics is mainly based on state-of-the art dynamic stochastic general equilibrium (DSGE) models which are based on fundamentals. However, these traditional models have difficulty explaining the observed booms and busts in housing prices. A series of papers by Shiller have argued that the changes in economic fundamentals such as population growth, construction costs, interest rates and real rents did not match up with the observed house price fluctuations (Case and Shiller, 2003; Shiller, 2007, 2008, 2012, 2015). Davis and Heathcote (2005) also suggested that DSGE models with housing consumption and production were unable to capture the instability of house prices.

During the last decades an increasing number of researchers have recognized economic systems as complex systems with multiple equilibria. Recently, a theoretical approach using heterogeneous agent models (HAMs) has been introduced to housing markets, inspired by the work on heterogeneous agent based financial market models; see, for instance, (Brock and Hommes, 1997; Brock and Hommes, 1998) and the comprehensive survey in Hommes (2013). Kouwenberg and Zwinkels (2015) developed and estimated a HAM model for the U.S. housing market, and showed that the estimated model produces boom and bust price cycles endogenously. Dieci and Westerhoff (2012, 2013, 2015) also investigated the speculative behavior in housing markets using a HAM approach, identifying a variety of situations leading to irregular endogenous dynamics with long lasting, significant price swings around the fundamental price, like those observed in actual markets. Bolt et al. (2014) established and estimated a HAM model for eight different countries, and found evidence of heterogeneous expectations from empirical data and identified temporary house price bubbles for various countries.

Although HAMs turned out to be successful theoretical tools to capture temporary deviations from market equilibrium, a related statistical time series analysis method is still lacking. In this paper, we therefore consider and compare various statistical methods to describe the price dynamics governing real housing price time series. Catastrophe theory has been suggested to be a good candidate approach for describing (parts of) the economy (Zeeman, 1974); it can capture the inherent instability in many nonlinear dynamical systems and has proven to be an extremely successful tool to investigate the qualitative properties in a wide range of different complex systems, ranging from physics and engineering to biology, psychology and sociology. Its applications involve urban and regional systems (Wilson, 2011), quantum morphogenesis (Aerts et al., 2003), the stability of black holes (Tamaki et al., 2003), the size of bee societies (Poston and Stewart, 2014), the cognitive development of children (Van der Maas and Molenaar, 1992), sudden transitions in attitudes (Van der Maas et al., 2003) and so on. In all these applications, the behavior of the observed system shows sudden and discontinuous changes or critical transitions as a result of a small change in one or more control variables. Catastrophe theory offers a mathematical basis for the number and the type of critical points for the classification of nonlinear dynamical systems. Since the economic system has become widely recognized as a complex system (see e.g. the special issue of JEDC on Complexity in Economics