



Error correction dynamics of house prices: An equilibrium benchmark



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ABSTRACT

Central to recent debates on the “mis-pricing” in the housing market and the proactive policy of central bank is the determination of the “fundamental house price.” This paper builds a dynamic stochastic general equilibrium (DSGE) model that produces reduced-form dynamics that are consistent with the error-correction models proposed by Malpezzi (1999) and Capozza et al. (2004). The dynamics of equilibrium house prices are tied to the dynamics of the house-price-to-income ratio. This paper also shows that house prices and incomes should be co-integrated, and hence provides a justification of using co-integration tests to detect possible “mis-pricing” in the housing market.

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1. Introduction

This paper has several aims. First, it contributes to an emerging concern on relating economic fundamentals to asset prices. For instance, many authors have discussed whether the housing boom that occurred before the 2008 crisis was due to “over-pricing”.¹ Obviously, the level of the “fundamental house price” (FHP) needs to be determined before the degree of “over-pricing” or “under-pricing” can be found. The potential issue of “mis-pricing” in the housing market is also related to the debate on the role of the central bank. Some authors argue that the central banks should act proactively once the asset prices (both of stocks and of housing) deviate significantly from the levels considered to be

consistent with economic fundamentals.² Even if everyone agreed to institute a “proactive” central bank, there remains a gap to be filled through identifying “*econometrically implementable*” tests that *define and detect* “*significant deviations*” in asset prices. In other words, an empirical determination of the FHP is central to both areas of debate. This paper extends the literature by providing a simple theory of house price dynamics when the housing market and the macroeconomy are driven solely by economic fundamentals. This

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¹ The literature is too large to be reviewed here. Among others, see Sowell (2009) for a review of the literature and related issues.

² For instance, the Economist (2011) summarizes that, “Since the financial crisis in 2007 central banks have expanded their remits, either at their own initiative or at governments’ behest, well beyond conventional monetary policy. They have not only extended the usual limits of monetary policy by buying government bonds and other assets. . . They are also taking on more responsibility for the supervision of banks and the stability of financial systems”. See also Taylor, 2009 for a related discussion. Clearly, there are alternative views on the related issues and the discussion is still on-going.

theory can then be used as a benchmark for detecting the “deviations” that are potentially “mis-pricing”.

Similar attempts have been made previously. For instance, [Malpezzi \(1999\)](#) relates the movement of house-price-to-income ratio to the house price dynamics and makes two conjectures. First, the house-price-to-income ratio is a constant in the long run (this conjecture is hereafter denoted by *M1*). Second, house price changes do not directly depend on price lag, but instead on the house-price-to-income ratio (in both the current period and previous periods) in a format that exhibits certain features of an error-correction model (this conjecture is hereafter denoted by *M2*). [Malpezzi's](#) paper clearly addresses the concerns of the general public in addition to those of official agents, as the house-price-to-income ratio is often used as a measure of whether house prices have deviated from “fundamental” prices. For instance, the [Wall Street Journal \(2011\)](#) comments that “. . . For decades, price-to-income levels have moved in tandem, with a specific housing market's prices rising or falling in line with local residents' incomes. Many economists say that makes the price-to-income ratio a good gauge for determining whether housing is undervalued or overvalued for a given market.” Regardless of whether all economists would agree with this statement, it reflects the situation as perceived by the media. In a research note of the Parliament of the United Kingdom, [Keep \(2012\)](#) comments that “*The ratio of house prices to income is a key indicator of the relative affordability of owner-occupation*”. A more systematic study of the relationship between house-price-to-income ratio and movements in house price may thus be of value.

In contrast, [Capozza et al. \(2004\)](#) assert that house prices follow a second-order difference equation *without income* explicitly appearing in the equation (this conjecture is hereafter denoted by *C1*). Their simple and elegant model finds support from a dataset with 62 metropolitan statistical areas (MSAs) in the United States from 1979 to 1995 (*hereafter*). More recently, [Glindro et al. \(2011\)](#) find support for *C1* from nine Asia-Pacific countries.³ Thus, *some common patterns* for house price dynamics seem to exist across countries.

Note also that while [Malpezzi \(1999\)](#) includes the house-price-to-income ratio in the empirical model, the model of [Capozza et al. \(2004\)](#) only contains house price information. These empirical models may thus represent different degrees of direct dependence of house prices on income. There are, of course, other possible forms of error correction models for house prices. For reasons of space, however, this paper focuses on building a simple model to relate directly to these empirical models. More specifically, this paper addresses the following questions arising from the two papers.

1. [Malpezzi \(1999\)](#) and [Capozza et al. \(2004\)](#), among others, provide empirical models for the dynamics of house prices while leaving the theoretical side open. Is there a

way to “rationalize” these empirical models of house price dynamics in an equilibrium setting with solid micro-foundation?

2. While these papers are innovative and insightful, the “error-correction structures” in their models deviate from that in conventional error correction models (ECMs). However, these models have achieved empirical successes. Can we provide a theoretical justification for their abstraction of the dynamics of income in models of house price?
3. Both [Malpezzi \(1999\)](#) and [Capozza et al. \(2004\)](#) use MSA data from the U.S. with almost identical sampling periods. Is it possible that there are some links between the two models?

This paper takes the first step to address these questions. In particular, this paper attempts to build a dynamic stochastic general equilibrium (DSGE) model in which both house prices and aggregate output are derived endogenously. The house price dynamics derived from this model can take a form that is similar either to (1) or to (2). In other words, we can reconcile (*M1*, *M2*, *C1*) in an *unifying framework*. Thus, this paper also establishes a strong link between the econometrics literature and the DSGE literature.⁴ It may be of interest independently because while error-correction models are often interpreted as evidence of “disequilibrium”, in this paper we derive an error-correction model for house prices in an equilibrium setting.⁵

This paper also contributes to the recent macro-housing literature. Providing a comprehensive survey of this emerging literature is beyond the scope of this paper;⁶ instead, a few contributions are highlighted. [Greenwood and Hercowitz \(1991\)](#) provides one of the earliest studies of the different allocation of business and household capital in a dynamic, general equilibrium setting. [Jin and Zeng \(2007\)](#) and [Ortalo-Magne and Rady \(2006\)](#), among others, place emphasize on collateral constraints and how the endogeneity of the house price provides feedback into the macroeconomy. [Iacoviello \(2005\)](#), [Iacoviello and Neri \(2010\)](#) and [Iacoviello and Pavan \(2012\)](#), among others, concentrate on the quantitative aspect and include calibration to match different aspects of the U.S. housing market and the macroeconomy. [Ried and Uhlig, 2009](#) build a two-sector DSGE model to numerically mimic the house-price-to-GDP ratio and the stock-price-to-GDP ratio. [Chen et al., 2012](#) study how house prices and mortgage premiums interact in a DSGE framework. Clearly, it is important

⁴ In some earlier literature, such as [Kydland and Prescott \(1996\)](#), DSGE is sometimes interpreted as a substitute of econometrics. In the more recent literature, such as those surveyed by [Fernandez-Villaverde \(2010\)](#), DSGE are often estimated with sophisticated econometrics techniques.

⁵ It is well known that the reduced form dynamics of the DSGE model can be summarized by a VAR structure and co-integration test can be performed, as demonstrated by [King et al. \(1991\)](#) and [King et al. \(2002\)](#), among others. To our knowledge, theoretically derive an error-correction structure and examine the cointegration relationship among variables in a DSGE model is rare, and this paper takes a preliminary step towards this direction.

⁶ Among others, see [Leung \(2004\)](#), [Leung \(2007\)](#), [Chang et al. \(2011\)](#) and [Van Nieuwerburgh \(2012\)](#), for a review of the literature.

³ The nine countries are Australia, China, Hong Kong, Korea, Malaysia, New Zealand, Philippines, Singapore and Thailand.

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