CHAPTER 11

Housing Bubbles

Edward L. Glaeser*, Charles G. Nathanson†
*Harvard University and NBER, Cambridge, MA, USA
†Northwestern University, Evanston, IL, USA

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Abstract

Housing markets experience substantial price volatility, short-term price change momentum, and mean reversion of prices over the long run. Together, these features, particularly at their most extreme, produce the classic shape of an asset bubble. In this chapter, we review the stylized facts of housing bubbles and discuss theories that can potentially explain events like the boom–bust cycles of the 2000s. One set of theories assumes rationality and uses idiosyncratic features of the housing market, such as intensive search and short-selling constraints, to explain the stylized facts. Cheap credit provides a particularly common rationalization for price booms, but temporary periods of low interest rates will not explain massive price swings in simple rational models. An incorrectly underpriced default option can make rational bubbles more likely. Many nonrational explanations for real estate bubbles exist, but the most promising theories emphasize some form of trend chasing, which in turn reflects boundedly rational learning.

11.1. INTRODUCTION

Between 2000 and 2012, America experienced a great housing convulsion that had all the classic features associated with real estate bubbles. Housing prices rose dramatically and then fell, leaving average real housing prices in 2012 no higher than they were in 2000. Price growth, between 2000 and 2006, was much higher in some places than in others, and the places with the biggest price growth experienced the largest declines. Surprisingly, some of the biggest booms occurred in places like Phoenix and Las Vegas, which appear to have few short-run limits on new construction (Davidoff, 2013; Nathanson and Zwick, 2013; Gao, 2014).

During the years of biggest boom—2003, 2004, and 2005—when the change in real housing price growth is regressed on the 1-year lag of price growth across metropolitan areas, the coefficient is greater than one. Price growth seemed to build upon itself. This phenomenon represents the more general tendency of price growth to show strong positive serial correlation at 1-year frequencies (Case and Shiller, 1989). There was also a clear pattern of spatial correlation, where a boom that started on the coast seems to have spread to neighboring inland metropolitan areas (Ferreira and Gyourko, 2012).

The US housing cycle that occurred between 2000 and 2012 is extreme but hardly unique. Other countries, such as Ireland and Spain, also experienced housing booms and crashes over those years. While Japan's housing market remained stable after 2000, Japan had experienced its own massive real estate cycle in the 1980s and early 1990s. American history is replete with examples of real estate booms and busts, from the days of the early

Republic to the American convulsion of the early 1980s. In summarizing these events, Glaeser (2013) argued that while these events may clearly look like bubbles ex post, even at their height, prices could be reconciled with standard models of real estate evaluation.

In Section 11.2 of this essay, we present a benchmark, rational model so that we can assess departures from this model when we discuss stylized facts. We use a simple user cost model of housing value that we refer to as the linear asset pricing model or LAPM, following Head et al. (2014). This approach runs deep within real estate and housing economics, but it differs from the general equilibrium approach preferred by macroeconomists and discussed by Davis and Van Nieuwerburgh in Chapter 12. In any user cost model that descends from Poterba (1984), prices equal the expected value of the exogenous flow of discounted future benefits from homeowning. While some empirical facts may be obviously anomalous, many housing facts are only surprising in the context of the model, which is why we begin with a simple model, rather than stylized facts.

The LAPM approach not only is rational but also abstracts away from critical institutional features of the housing such as search and heterogeneity. Section 11.2 also discusses important institutional features of the housing market that differ from other assets including the extreme difficulty of short sales, the extreme heterogeneity of the asset, the dominant role of amateur investors, and the limited information about current asset values. These differences do limit the widespread applicability of the user cost or LAPM formula, but it remains a useful benchmark with which to examine housing price fluctuations.

Section 11.3 discusses stylized facts about housing markets. Housing markets do experience excess variance of price changes relative to the LAPM's predictions, but excess variance is less endemic than in other asset markets and shows up primarily in brief outbursts. A few overoptimistic traders will more readily dominate standard asset markets than the highly democratic housing market, which might explain the apparently more stable nature of housing markets most of the time (Nathanson and Zwick, 2013).

Section 11.3 also notes the spatial heterogeneity of the recent boom and bust, the strong short-term positive serial correlation of prices, and the even stronger long-term negative price change serial correlation. The short-term positive serial correlation is difficult to square with the LAPM, but negative serial correlation over longer time horizons is more readily reconcilable with rationality if housing supply responses are delayed. We also discuss the movements in the quantities of housing, which can refer to both the volume of housing produced and the volume of housing sold. We end this section with a discussion of real estate bubbles in US history that draws heavily from Glaeser (2013).

Section 11.4 turns to rationalizing the seemingly irrational: economic approaches to understanding these gigantic fluctuations, which maintain individual rationality assumptions. Models of search by heterogeneous consumers, such as Novy-Marx (2009), Genesove and Han (2012), Head et al. (2014), and Guren (2014), can amplify shocks to the housing demand and thereby generate momentum in prices over shorter time

periods. Heterogeneous demand can also generate price volatility, if there are exogenous shocks to supply. We discuss the possible role of rational learning but conclude that fully Bayesian updating has little power on its own to explain the stylized facts.

Our final attempt to explain the events with rational models is to discuss the possible role of credit. Mian and Sufi (2014) have compellingly made the case that subprime lending did push up prices in many areas. While lower interest rates will have only a modest impact on prices in the standard LAPM, assuming that individuals anticipate the mean reversion of interest rates (Cox et al., 1985), an underpriced default option will allow rational bubbles to occur more readily. One natural explanation for charging borrowers too little for the risk of default is the existence of agency problems either within financial institutions or between mortgage originators and the eventual owners of securitized mortgages. We do not formally model the financial institution's structure but assume that for some rational reason, the agents of lenders are pushing cash out the door too quickly and cheaply. Naturally, overly cheap credit might also reflect overoptimism on the part of lending institutions or some other form of limited rationality.

Typically, rational bubbles in housing require a violation of the standard transversality condition (Malinvaud, 1953): with such bubbles, the discounted infinite horizon expected value of the home is strictly positive.[1] Violations of the transversality condition make the problems of builders and sellers difficult to explain: why ever sell a house today when its price is rising so quickly? As such, rational bubbles are particularly difficult to deliver with even moderately elastic supply (Glaeser et al., 2008). If default risk is underpriced, then rational bubbles can occur even with moderately elastic supply and without violating any transversality condition. Naturally, underpriced default risk might itself reflect bounded rationality, or alternatively, it might reflect an agency problem within lending institutions.[2]

In Section 11.5, we present a collection of less rational models of housing bubbles. We begin with models in which beliefs are exogenous including Glaeser et al. (2008), Piazzesi and Schneider (2009), and Nathanson and Zwick (2013). These models are useful for exploring the ways in which institutional features of the housing market interact with irrationality. For example, Glaeser et al. (2008) and Nathanson and Zwick (2013) both considered land availability; Piazzesi and Schneider (2009) considered search dynamics. While this line of work is potentially useful in generating ancillary predictions about housing bubbles (e.g., they are most common in areas where land supply is limited in the long run), they cannot explain the ultimate source of beliefs about house prices.

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[1] The transversality condition helps ensure that a dynamic competitive equilibrium is Pareto optimal. This does not imply that the transversality actually holds in actual asset markets, but its critical role in a number of important theorems should make us wary of dropping it arbitrarily.

[2] For example, if banks can't observe credit quality but can observe loan amounts and if lending takes effort, then the bank may want to reward loan officers based on the number of loans made to induce more effort. This may lead to low-quality loans.

We then turn to a second major class of models: extrapolation. In one class of extrapolative models, the belief formation process is ad hoc but assumed for a small class of traders. In a second class, the belief formation process follows from imperfect learning about a stochastic growth rate. In a sense, the first class assumes massive irrationality for the few, while the second class assumes modest irrationality for the many. It may be that the first is more appropriate in standard financial markets where a small number of well-financed traders can drive markets, while the second class is more appropriate in housing markets.

A third class of models discusses other forms of limited rationality, including limited memory, basing models on short runs of data, rule-of-thumb buying strategies, and price estimates based on natural geographic comparisons. This discussion highlights the fact that once perfect rationality is dropped, an essentially infinite array of assumptions is possible. This is Tolstoy's corollary: There is only one correct answer to an optimization problem, but there are an uncountable number of wrong answers.

Yet, there are some insights from near-rational that seem more important than others. Fuster et al. (2010) introduced natural expectations where individuals forecast the future using simple models, perhaps incorporating only a limited amount of history. Short-history forecasting may lead homebuyers to ignore low-frequency mean reversion and the longer-term impact of elastic supply, which will eventually reduce prices. Glaeser (2013) argued that the failure to internalize the long-run impacts of elastic supply on price is a constant feature of US real estate history. We end Section 11.5 by discussing social learning and the possible role of entrepreneurs, like real estate brokers, who attempt to persuade buyers that housing prices can only go up.

Finally, in Section 11.6, we discuss public policy implications of real estate bubbles. Two facts seem clear: Real estate fluctuations exist, and they have displayed a remarkable ability to wreak havoc on financial systems. While it may be impossible or infeasible to prick bubbles while they expand, it may still be possible to undertake protective actions to ensure that the bursting of the bubble will not cause as much damage in the future. There may also be social benefits from reconsidering those policies that encourage individuals to borrow heavily to invest in real estate. Section 11.7 concludes.

11.2. THE LINEAR ASSET PRICING MODEL AND THE IDIOSYNCRASIES OF HOUSING

In Section 11.4, we will present the core stylized facts about the housing market that need to be addressed by the models of housing bubbles. For these facts to help inform a survey of housing bubbles, we must start with some clarifying discussion and algebra. Bubbles are typically defined as periods in which asset prices "run well above or below the intrinsic value" (Fama, 1965). In the real estate context, fundamentals can mean either the value based on the flow of rents, as in the "user cost" model and its LAPM variant, or the flow of well-being associated with living in a particular spot.

Housing markets are different from other asset markets. There exist real estate linked assets, including real estate investment trusts (REITs) or collateralized mortgage securities, that trade in large markets, but, more typically, housing is bought and sold in small, decentralized transactions. This fact is obviously true in the enormous market for single-family housing, but it is also true in the realm of commercial real estate as well. The dollar amounts of each sale may be larger, but ultimately, the purchase of Rockefeller Center is just as idiosyncratic as the purchase of that Tudor home on the corner, if not more so.

11.2.1 The linear asset pricing model or user cost model

Nonetheless, the benchmark model of housing prices, often called the "user cost" model, assumes that there is a single price of housing that is paid by all buyers, who are typically homeowners.[3] This price follows from an intertemporal no-arbitrage condition. The value of owning a home equals the benefits today plus the asset value tomorrow, or the price P_t equals $R_t + \frac{E(P_{t+1})}{1+r}$, where R_t represents net benefits of owning during time t, and $\frac{1}{1+r}$ represents a constant discount factor. The "fundamental" value then equals $E\left(\sum_{j=0}^{\infty}(1+r)^{-j}R_{t+j}\right)$. Empirically, the values of R_{t+j} are either associated with observed market rents (Himmelberg et al., 2005) or the benefits of living in a particular area including amenities and income (Glaeser et al., 2014; Head et al., 2014). These raw series can provide testable implications for the observed series of prices.

One important aspect of this approach is that it avoids any consideration of risk aversion and portfolio composition. These issues are particularly important to the financial economists and macroeconomists who study housing, and they are addressed in Chapter 12 by Davis and Van Nieuwerburgh.

Shiller (1981) provided a famous, nonparametric approach to testing for excess variance by noting that since $\sum_{j=0}^{\infty}(1+r)^{-j}R_{t+j}$ equals $E\left(\sum_{j=0}^{\infty}(1+r)^{-j}R_{t+j}\right) + \text{Error}$ and since the error should be independent of the expectation, the variance of the fundamental must be greater than the variance of the price series. Of course, this is not true in the US stock market, and it is not true in housing markets either. This calculation is also somewhat compromised by time-varying discount factors, which we will address later.

For work on housing markets, it is somewhat more common to assume a particular stochastic process for the fundamental, R_t, and to work with the formula implied by that quantity. We briefly consider the implications of four stochastic processes: $R_t = (1+g_R)R_{t-1} + \epsilon_t^R$ (constant growth, i.i.d. error), $R_t = R_{t-1} + \epsilon_t^D + \theta\epsilon_{t-1}^D$ (no growth, moving average error), $R_t = \delta R_{t-1} + (1-\delta)\overline{R} + \epsilon_t^D + \theta\epsilon_{t-1}^D$ (mean reverting, moving average error, e.g., ARMA(1,1)), and $R_t = R_{t-1} + g_t + \epsilon_t^D$, where $g_t = \lambda g_{t-1} + (1-\lambda)\overline{g} + \epsilon_t^g$ (stochastic growth rate). The moving average process can create

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[3] Haughwout et al. (2011) reminded us that during the boom, many of the buyers of single-family homes were actually investors.

some persistence in price changes but much less than the persistence in rent changes. The mean-reverting process can create robust amounts of price mean reversion but very small amounts of price momentum. The stochastic growth rate process can predict both mean reversion and at least modest momentum. That process can also yield relatively high levels of price variance.

The simplest, nonstochastic process is to assume a constant growth rate for R_t, so that $R_t = (1 + g_R)R_{t-1} + \epsilon_t^R$, where ϵ_t^R is an independently and idiosyncratically distributed (i.i.d.) noise term. In that case, the LAPM price becomes $\frac{(1+r)R_t}{r-g_R}$. One implication of this formula is that small differences in g_R can generate extreme differences in prices, especially when interest rates are low, as Himmelberg et al. (2005) emphasized. Since the LAPM version of the user cost model can imply extremely high price–rent ratios with seemingly reasonable parameter estimates, it can also make bubbles seem rational. The use of the LAPM in 2006 to justify the high prices at the peak of the cycle suggests just how difficult it can be to identify a bubble while it is happening.

Shiller's (1981) insight was that even if it is hard to tell which price levels are compatible with an LAPM price, the model also yields predictions about price change variances and covariances that can be rejected by the data. The constant growth rate with i.i.d. error assumption implies that the standard deviation of price changes equals $\frac{1+r}{r-g_R}$, or the price–rent ratio, times the standard deviation of ϵ_t^R, which is also the standard deviation of changes in the rent. In other words, the ratio of standard deviation of price changes to the standard deviation of rent changes equals the price–rent ratio. That fact holds true for all time intervals, because the shocks are i.i.d. Moreover, this simple random walk with drift predicts neither positive serial correlation in short-term price changes (momentum) nor negative serial correlation in long-term price changes (mean reversion).

11.2.2 Processes with momentum, mean reversion and stochastic growth rates

For the next two illustrative processes, we assume that $g_R = 0$. Given this simplification, we next complicate the shocks with a moving average component and assume that $R_t = R_{t-1} + \epsilon_t^D + \theta \epsilon_{t-1}^D$, where ϵ_t^D is i.i.d. and $\theta \leq 1$. The implied LAPM price is $\frac{(1+r)R_t + \theta \epsilon_t^D}{r}$. The ratio of the standard deviation of price changes to the standard deviation of rent changes is $\frac{1}{r}\sqrt{\frac{(1+r+\theta)^2 + \theta^2 r^2}{1+\theta^2}}$. The serial correlation of rent changes is $\frac{\theta}{1+\theta^2}$, and the implied serial correlation in price changes is $\frac{(1+r+\theta)r\theta}{(1+r+\theta)^2 + \theta^2 r^2}$, which must be less than $\frac{r\theta}{1+\theta^2}$. This implies that the serial correlation of prices must be less the interest rate times the serial correlation in prices. If $r = 0.1$, then an increase in the value of θ from 0 to 1 causes the serial correlation of rents to increase from 0 to 0.5, but the serial correlation of housing prices will rise only from 0 to 0.0475. Very large amounts of serial correlation in rents are associated with quite modest amounts of serial correlation in price changes.

This moving average process does little to generate mean reversion at lower frequencies. To allow for this possibility, we assume that $R_t = \delta R_{t-1} + (1-\delta)\overline{R} + \epsilon_t^D + \theta\epsilon_{t-1}^D$. The LAPM price satisfies

$$P_t = \frac{(1+r)R_t}{1+r-\delta} + \frac{(1+R)(1-\delta)\overline{R}}{r(1+r-\delta)} + \frac{\theta\epsilon_t^D}{1+r-\delta} \tag{11.1}$$

Generating mean reversion at longer frequencies is feasible with this type of autoregressive process, but generating substantial momentum is even more difficult than in the simpler moving average process discussed above. A shock from last period can increase price growth today, as long as $\theta > \frac{(1+r)(1-\delta)}{r}$. This will hold if $\delta = 1$, which is the random walk case discussed above, but with higher levels of mean reversion, even one-period momentum becomes less and less plausible, and it is still impossible to get price change momentum that is nearly as big as rent change momentum.

Last, we consider stochastic growth rates. We assume that $R_t = R_{t-1} + g_t + \epsilon_t^D$, where $g_t = \lambda g_{t-1} + (1-\lambda)\overline{g} + \epsilon_t^g$. The growth rate is persistent in the short term but ultimately reverts to the area level norm. These assumptions also imply that the LAPM price satisfies

$$P_t = \frac{(1+r)R_t}{r} + \frac{(1+r)^2(1-\lambda)\overline{g}}{r^2(1+r-\lambda)} + \frac{(1+r)\lambda g_t}{r(1+r-\lambda)} \tag{11.1'}$$

The ratio of the standard deviation of price changes to the standard deviation of rent changes is again roughly similar to price–rent ratios. The one-period autocorrelation of rental shocks is $\frac{\lambda}{\varphi(1-\lambda^2)+1}$, where $\varphi = \frac{\mathrm{Var}(\epsilon_t^D)}{\mathrm{Var}(\epsilon_t^g)}$. The one-period autocovariance of price changes equals $\frac{(1-\lambda^2+r)(1+r)^2\lambda}{r(1+r-\lambda)^2(1-\lambda^2)}\mathrm{Var}(\epsilon_t^G)$, which is distinctly positive. The long stickiness of growth rates in fundamentals provides the best chance of hitting high degrees of serial correlation in housing prices.

We have required the LAPM, so far, to only concern fundamentals, but as with most asset pricing equations, the one-period indifference condition $R_t + \frac{1}{1+r}E(P_{t+1}) = P_t$ admits "rational bubbles," where $R_t + \frac{1}{1+r}E(P_{t+1} + \mathrm{Bubble}_{t+1}) = P_t + \mathrm{Bubble}_t$. The key requirement is that $\frac{1}{1+r}E(\mathrm{Bubble}_{t+1}) = \mathrm{Bubble}_t$. Such a bubble would violate the standard transversality condition requiring the discounted value of future housing prices to converge to zero as t goes to infinity. The bubble's discounted value at all time periods will always equal its value today.

In their most plausible formulation, rational bubbles are stochastic, so, for example, the bubble will burst in each period with probability ν. In this case, the bubble multiplies by $\frac{1+r}{1-\nu}$ during each period that it doesn't burst. While this formulation is mathematically conceivable, it requires buyers to expect that with some probability, housing will become extraordinarily expensive within some reasonable probability. For example, a Las Vegas house in 2006 was valued at $300,000 and one-half of that was a rational bubble: the

market dropped by over 50% after the bust. Moreover, assume that buyers thought that there was a 50% chance that the bubble would burst in each year and that $r=0.05$. If the bubble didn't burst, the home would have been worth \$465,000 in 2007 (with probably 0.5), \$811,500 in 2008 (with probably 0.25), and \$1.54 million in 2009 (with probably 0.125).

Is such price growth remotely plausible and is it compatible with other features of housing markets? Glaeser et al. (2008) argued that such price growth is incompatible with even moderately elastic supply. Presumably, builders in Las Vegas in 2009 would do anything to build houses that can be sold for such high prices. Moreover, this \$1.54 million dollar house would have to find buyers, at least some of whom need down payments. Would it be possible for price differences between similar regions to widen so extraordinarily and persist in expectation? As we will discuss later, we find this rational bubble formulation far more plausible if it occurs in a setting where lenders are providing borrowers with an underpriced default option.

11.2.3 What is special about housing?

While the LAPM model treats housing essentially as a standard security, this assumption is badly at odds with reality. Housing is idiosyncratic and traded individually. Searching for housing can be a lengthy process. We now discuss how the salient aspects of the housing market make housing somewhat different from other securities.

This dispersed, idiosyncratic market means that there is no such thing as the current price of housing, in the same way as there is a current price of General Electric stock. Moreover, across the United States and even across the larger metropolitan areas, the heterogeneity of markets is enormous. Between 2004 and 2006, FHFA price data show the value of homes in Phoenix increasing by over 50%. In nearby Albuquerque, New Mexico, prices rose only 17% over the same time period. In Fort Collins, Colorado, real prices actually fell during those 2 years.

Abel and Deitz (2010) divided American housing markets into four groups based on their experiences from 2000 to 2008. Many had booms and busts, and many avoided both booms and busts. A smaller number experienced booms without busts, like Casper, Wyoming. Even fewer areas, most notably Detroit, Michigan, experienced busts without booms. Cyclical activity also differs substantially across countries, and ideally, housing models could also explain this heterogeneity.[4]

The fragmented housing market may help explain why post-boom drops are so much slower in housing markets than in other asset classes. The history of the US stock market is punctuated by particular days of infamy during which shares tumbled, such as 24 October 1929 (Black Tuesday), 19 October 1987 (Black Monday), and 15 October 2008. There

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[4] Differential housing supply elasticities across countries may explain some of these differences (Caldera and Johansson, 2013).
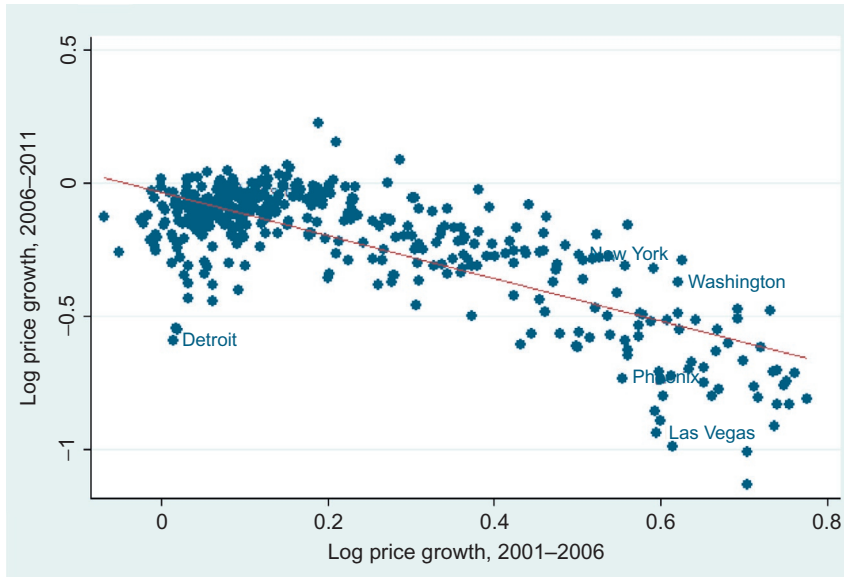
Figure 11.1 Real price growth (FHFA), 2001–2006 versus 2006–2011.

is no comparable date in which housing prices plummet. During the last two general housing market slumps, it took several years for prices to hit the bottom.

This slow adjustment process may also reflect transaction costs in housing, which slow sales and even price adjustments or the markets' domination by "amateurs." Ordinary homebuyers and sellers may have less up-to-date information than professional stock traders. These amateurs may also suffer more from "loss aversion" (as in Genesove and Mayer, 2001), which makes sellers unwilling to cut their asking prices even in the face of a market collapse.[5] This loss aversion might also explain why market volumes drop dramatically during busts. Scheinkman and Xiong (2003) connected the high levels of trading during financial booms to heterogeneous beliefs, and that also seems likely to be relevant in housing markets.[6]

The market fragmentation of housing also helps explain why housing market "facts" tend to be cross-sectional as much as time series. For example, the mean reversion of housing prices is often illustrated by a cross-sectional graph, such as Figures 11.1 and 11.2, showing the strong correlation between the degree of price growth during a boom period and the degree of price decline during the bust. Indeed, the tendencies of local real estate markets towards excess variance, high-frequency momentum, and lower-frequency mean reversion show up even controlling for national market trends.

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[5] We thank William Strange for emphasizing these points.
[6] Hong et al. (2006) also connected bubbles and volume, but their analysis also relies on lock-up constraints, such as those that faced Internet entrepreneurs.
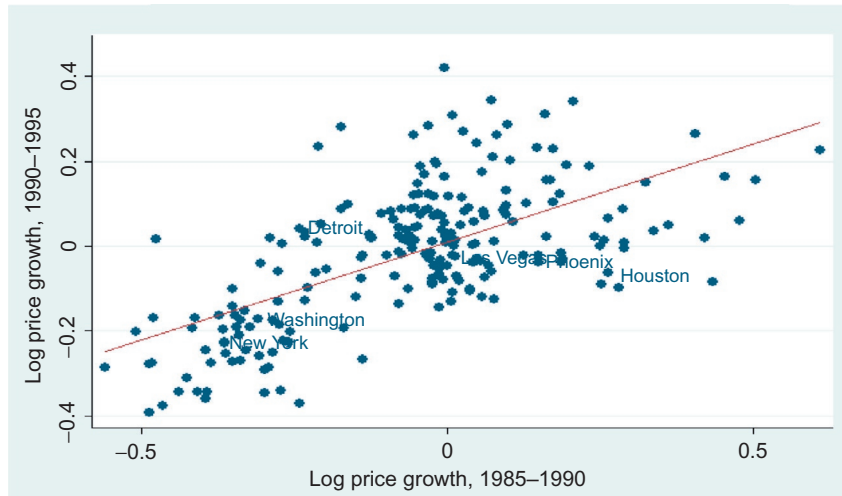
Figure 11.2 Real price growth (FHFA), 1990–1995 versus 1985–1990.

The fragmented nature of local housing markets also explains why housing economists rely on two distinct no-arbitrage conditions to measure "appropriate" housing values. In the temporal user cost model, the flow benefit of owning a house at time t, plus the discounted value of the home at time $t+1$, must equal the cost of buying the house at time t (P_t) plus other costs such as taxes and effort involved in maintenance. The alternative, spatial no-arbitrage condition is that the cost of living in Place A must equal the cost of living in Place B plus whatever extra benefits accrue to living in Place A relative to Place B, as in the Alonso–Muth–Mills model. Both equations are complicated by idiosyncrasies of mortgage borrowing, risk aversion, and transaction costs, but they provide useful starting points for thinking about asset prices and real estate bubbles.

Implementing this simple intertemporal user cost formula is challenged by the difficulty of observing most of the key parameters. Prices may be seen by the econometrician but little else can be directly observed. While the benefit of owning stocks for ordinary stockholders yields only dividend yields and price appreciation, the primary benefit of owning a home is that you get to live in the home and that may yield different benefits for different people. Moreover, ownership carries other costs. Some of these costs are directly observable, like property taxes, while others, such as the sweat of home care, are not. Limited observability of costs and benefits means that the no-arbitrage condition in housing will always be far less precise than the equivalent conditions in other asset markets.

The most straightforward means of quantifying the benefits of owning is to use rents. If owning and renting were otherwise identical, then the benefits of owning should be equal to the benefits of renting. Yet, there are three reasons why identifying the flow

value of owning housing with the prevalent rental rates is problematic: The homes aren't the same, the neighborhoods aren't the same, and the unobserved costs aren't the same. Glaeser and Gyourko (2009) documented that the observable differences between rental and owner-occupied structures are enormous: 64% of owner-occupied units are single-family detached as opposed to 18% of rental units. Owner-occupied units are also less likely to be located in central cities and more likely to be in neighborhoods that are rated as excellent by their residents. Finally, Goodman (2005) used the 2003 American Time Use Survey and documented the significantly large amounts of time spent on home and yard maintenance by owners, but it is hard to quantify the costs of that effort.

An alternative approach is to eschew rental data as being nonrepresentative and instead focus on measuring the benefits of locating in one metropolitan area, rather than another, following Rosen (1979) and Roback (1982). Local earnings and amenities are the typical sources of local benefits, but amenities are difficult to completely capture and the earnings of the marginal homebuyer are also not directly observed. Finally, since this approach is inherently comparative, it can only answer whether the fluctuations in price in one area seem reasonable relative to the fluctuations in price in some other place.

Housing is also different from stocks and bonds because housing is the democratic asset, owned by over 60% of American households. Policies and preferences come together to ensure that homeownership is dispersed among millions of Americans, rather than concentrated in the hands of professional investors who rent them out. For these households, especially those with long horizons, housing looks more like a consumption good than a financial asset. Some caution therefore is needed while applying models typically used with the stock market to the housing market, especially since we are all born short housing. Of course, some parts of the real estate market—like commercial properties, undeveloped land, and rental residential houses—are owned by investors calculating discounted future cash flows, and residential housing resembles a financial asset more in areas with these other types of properties (Nathanson and Zwick, 2013).

The widespread nature of housing ownership also creates policy-related issues relative to housing booms that are less present with other asset classes. Historically, housing risk was held by homeowners and by savings institutions. When a boom crashed, millions of ordinary people were worse off, and the banking system was imperiled. The widespread nature of the pain and the potentially disastrous consequences of a banking system meltdown make serious policy response far more likely than when there is a bust in some smaller asset class. Few policy makers argued that indebted investors in Internet stocks had no obligation to repay their creditors in 2002, while many advocated against foreclosing on distressed homebuyers in 2008.

Short-selling housing is hard and that contributes to the difficulty of arbitraging housing markets. It was hard for smart money to bet against booms, like Las Vegas in 2005. Short sales are made particularly difficult because of a lack of asset interchangeability (Nathanson and Zwick, 2013). Normally, a short is achieved by borrowing an asset from

someone else, selling that asset and then promising to buy it back. Enormous variation in characteristics across houses makes such a home short sale process almost impossible. Short-selling collateralized debt obligations or REITs are considerably easier, but these assets are quite different than ordinary homes.

Glaeser and Gyourko (2009) pointed out that other, even simpler, modes of arbitrage, such as delaying eventual purchases, are difficult to exercise because delaying a sure purchase introduces large amounts of risk in the portfolio of any average household. The limits of arbitrage in asset markets typically increase the possibility that prices will deviate from fundamentals (Shleifer and Vishny, 1997). The extreme limits of arbitrage in housing may make those deviations even larger.

A final peculiarity of housing markets is that the endogenous supply of new housing is so obvious that it cannot be ignored, while asset pricing economists routinely treat the supply of assets as being fixed. America built over 9 million new housing units between 2002 and 2006. In 2005 alone, Las Vegas permitted almost 40,000 new housing units and Phoenix permitted over 60,000. Hall (2003) emphasized that there is also a supply of Internet start-ups that surely should have influenced the willingness to pay for shares of existing companies in 2000, but many models of speculation treat the supply of assets as fixed.

During historic housing booms, price growth has typically been tempered in areas with long-run elastic supply. Between 1996 and 2006, nominal price growth was $3 \times$ higher in areas where housing supply is inelastic than in areas where housing supply is elastic (Glaeser et al., 2008). Yet, many elastic cities experience large price increases as well during housing booms. For instance, Las Vegas and Phoenix and cities in Florida and inland California—places with very elastic housing supply—witnessed many of the largest price increases in the nation between 2000 and 2006 (Nathanson and Zwick, 2013).

In our own research, we have taken different but complementary approaches to explaining these elastic price booms.[7] Nathanson and Zwick (2013) argue that this phenomenon occurs in areas where housing supply is elastic today but will become inelastic soon. An example would be a growing city approaching a long-run development barrier. Investors speculate in the land markets about what the city will look in the future where new construction is difficult. This speculation leads to a boom and bust in the housing market, while the undeveloped land facilitates construction during the boom.

Glaeser (2013) took a different approach and argued that ignoring the impact of elastic supply is a pervasive error made by real estate speculators in the United States throughout the century. In many of these episodes, it took time for housing supply to come on line. When speculators don't realize supply is adjusting gradually, price booms occur that are followed by busts.

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[7] Gao (2014) and Sockin and Xiong (2014) also studied this phenomenon.

These theories differ in their predictions for what precipitates the bust. According to Nathanson and Zwick (2013), the bust occurs when optimistic land speculators learn that their rosy beliefs were incorrect. In Glaeser's (2013) argument, the bust happens when supply is finally able to adjust. The recent elastic booms fit the former theory better. Construction was high throughout the boom in these cities and not just at the end. Furthermore, consumer demand started to weaken in 2006 (Mian and Sufi, 2010), suggesting that belief revisions about household demand coincided with the beginning of the bust. Glaeser's (2013) mechanism better captures some historic episodes, such as the New York skyscraper boom of the 1920s, where construction was difficult to supply quickly due to new technologies.

Our theories both depart from standard theories of rationality but in different ways. Glaeser (2013) assumed that all market participants make the same common error of underforecasting future supply. This type of mistake has been suggested in other markets as well (Hoberg and Phillips, 2010; Greenwood and Hanson, 2013). In many US cities, ignoring new local supply is largely irrelevant—the number of new homes is sufficiently small, and a general decision to ignore the supply side is reasonable. More generally, given that economists believe that teaching economics has some value added, perhaps we shouldn't be surprised that most Americans are not innately gifted at grasping the workings of supply and demand.

In contrast, Nathanson and Zwick (2013) assume only that a few well-capitalized investors are very optimistic. This aspect is a feature because it involves a smaller aggregate deviation from rationality. But it also poses problems, because homeowners must disagree with the optimistic valuations of houses and buy them anyway. It is certainly possible that homebuyers desperately wanted to move to Las Vegas in the 2000s at any price and bought housing expecting a capital loss. Nathanson and Zwick (2013) show that short selling of homebuilders that held large land portfolios increased during the boom, consistent with the existence of pessimists. But pessimistic homebuyers aren't representative of the common way of looking at the housing market.

11.2.4 Directions for future research

The user cost model itself is so well developed that further research on it is unlikely to yield rich results. Yet, there could be some benefits to developing a more comprehensive set of theorems about the connection between the underlying benefit stochastic process and the implied price series. For example, it would be nice to know what the available moments of price series imply for the possible range of unobserved local benefit ("rent") series.

By contrast, many of the unique aspects of housing haven't been integrated fully into financial models of housing markets, which often treat housing as just another asset. Despite considerable progress in these areas, we lack general theorems about how

housing price series are influenced by the fact that housing is bought and sold only by paying extremely high transaction costs and typically after considerable search. We still know too little about the connection between endogenous supply and price fluctuations.

One natural means of identifying the impact of housing-specific phenomena is to examine related markets that differ in small ways from housing. For example, commercial real estate shares many of the same attributes as residential real estate, yet it is typically held by dispersed owners but by asset managers with large portfolios. REITs can be sold short, while privately held developments cannot, so examining REITs allows us to assess the impact of yet another particular feature of housing markets.

11.3. EMPIRICAL REGULARITIES OF HOUSING DYNAMICS

At this point, we turn to the empirical regularities of real estate dynamics. In some cases, these figures are intrinsically interesting, but in many cases, we are interested primarily in whether these facts are compatible with the simple LAPM or user cost model. We are interested primarily in facts that seem somewhat anomalous and hence particularly worthy of future research. We chose to present facts after first discussing the benchmark LAPM or user cost model precisely because facts can only be anomalous unless they conflict with the predictions of a basic model.

We divide this discussion into four subcategories. First, we discuss excess variance in price movements relative to fundamentals. Since Shiller (1981), excess variance has been the biggest puzzle in asset markets more generally, and it is also a significant puzzle in housing. We then discuss short-term momentum and longer-term mean reversion of housing. We then turn to facts about quantities, rather than prices, by which we mean sales, vacancies, and the amount of new construction. Finally, we end with a brief review of the longer history of real estate movements. This last discussion draws heavily on Glaeser (2013).

11.3.1 Excess variance

Real estate is subject to fluctuations that are larger than they seem to be justified by fundamentals—just like other asset markets (e.g., Shiller, 1981). If these fluctuations are not caused by underlying fundamentals, then they fit the standard (Fama, 1965) notion of bubbles: price movements not caused by fundamentals. But this excess volatility is not uniform across time periods. Housing can be quite steady for many years, but there are periods when housing prices move far more dramatically in ways that are quite hard to square with fundamentals.

How big is the standard deviation of price changes for metropolitan area housing markets? Glaeser et al. (2014) report that the standard deviation of 1-year price changes in the United States ranges from $2000 in the Sun Belt to $13,300 in coastal cities over the 1990–2004 period. Five-year price volatility ranges from $5400 in the Sun Belt to $48,000 in coastal cities. Using the entire sample of cities for which FHFA data are

available, we estimate a standard deviation of price changes over the 1980–2004 period of slightly under $10,000.

Are these numbers large or small? If they are benchmarked against changing rent values, they seem slightly large during the early time period. The standard deviation of rent changes using the REIT data suggests a standard deviation of about $623 of annual rent changes. Thus, over the 1980–2004 period, the standard deviation of price changes is about $16 \times$ higher than the standard deviation of rent changes. But this difference is not wildly out of line with the price–rent ratio over the same period, so the price variance doesn't seem all that excessive.

The same picture emerges when we compare price changes with the changes predicted by changes in income. Glaeser et al. (2014) compare price changes with those predicted by volatility in income, at least as measured by the average income of buyers found using the HMDA data. The volatility of prices over the 1990–2004 period is roughly similar to that predicted by income volatility. If BEA data on personal income across the entire metropolitan area are used instead of the income of new buyers alone, then the price volatility does appear to be significantly too high in coastal metropolitan areas. Head et al. (2014) similarly find variances that are in line with those predicted by a simple housing model.[8]

The real excess variance appears during periods, like that between 2001 and 2010, when prices temporarily explode (Wheaton and Nechayev, 2008). During this period, rents were relatively constant, and incomes didn't move much. Yet, the standard deviation of price changes is over $20,000. This is an extraordinary amount of variation across metropolitan areas that doesn't appear to be related to any obvious changes in fundamentals. Figure 11.3 shows the path of rents and prices in Boston and San Francisco, where it is obvious the rents had peaked and were falling before the housing price boom crested.

As such, the data do not suggest that housing prices display the same ubiquitous excess variance found in many other asset classes. Instead, housing prices experience brief moments of extreme variance that punctuate longer periods of general stability. For example, the 1991–1996 period was an era of extraordinary price stability across America's metropolitan areas. If this view is correct, then the puzzle is not to explain constant price variation, but rather periods when prices briefly explode and then tumble.

11.3.2 The shape of the cycle: short run momentum and long run mean reversion

For most observers, bubbles are embedded in real estate cycles and those cycles have features that go beyond excess asset price variance. A price series, $P_t = \hat{P}_t + \mu_t$, where

[8] Other approaches find somewhat more excess volatility. Gelain and Lansing (2014) found excess volatility in price–rent ratios relative to "a simple Lucas-type asset pricing model." Ambrose et al. (2013) found excess price volatility over a 355-year period in the Netherlands relative to fundamentals.
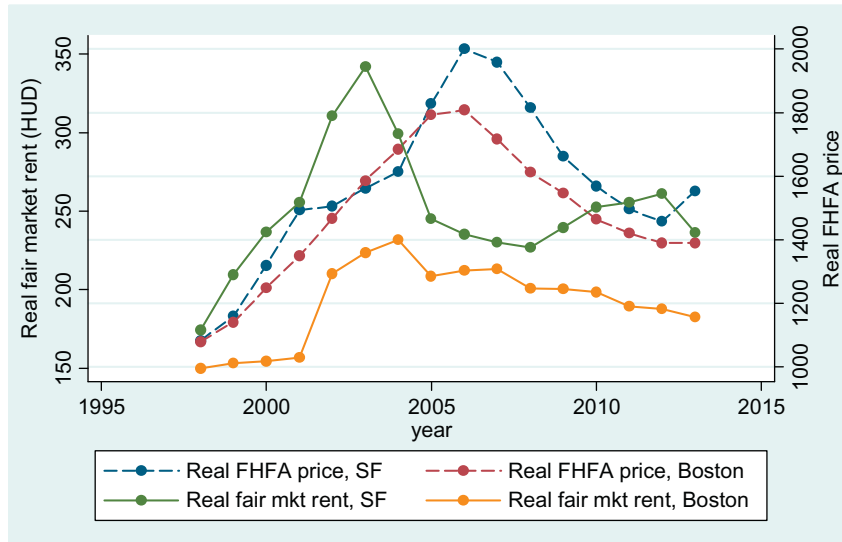
Figure 11.3 Price and rent growth for Boston and San Francisco. *Source: FHFA and HUD. Rents and prices in 2013 dollars.*

P_t is the realized price, $\hat{P}_t$ represents the price based on fundamentals, and μ_t reflects idiosyncratic white noise, independently drawn each day or every week, would fit Fama's (1965) definition of a cycle, but it would not capture the price movements that are often associated with major bubbles. Such a price series would be manic indeed, but not sustained, and manic high-frequency movements would have little impact on investment and probably not much on financial systems either.

In the popular view, influenced by classic descriptions such as Kindleberger (1978), the courses of bubbles have a defined shape. They begin with an early uptick, perhaps representing real good news or a little bit of early froth. That surge escalates, and during this growth period of the bubble, price growth escalates and the path of prices is convex. Ultimately, the bubble ends either in a violent crash or in a slow deflation.

Just like other markets, housing price changes display positive serial correlation at higher 1-year frequencies and mean reversion at lower frequencies like 5-year periods (Cutler et al., 1991; Glaeser et al., 2014). In normal periods, this momentum and mean reversion just seem like the normal course of affairs. During a great housing price event, such as the period between 2000 and 2012 for the United States or the 1980s boom and subsequent bust in Japan, the momentum and mean reversion define the shape of a bubble's path.

Over the 1980–2004 period, the one-period serial correlation of prices ranges from 0.75 in coastal metropolises to 0.6 in the Sun Belt, when we allow city-specific trends. The raw coefficient when prices are regressed on lagged price changes across the entire

sample from 1980 to 2012 is about 0.63 with or without city–specific trends. Head et al. (2014) report an even larger coefficient of 0.75.

These figures are remarkably high relative to the serial correlation of either rent or income changes. Both of these numbers are approximately 0.25. In the benchmark dynamic urban model of Glaeser et al. (2014), that serial correlation in fundamentals implies a price correlation that is essentially zero. The search model of Head et al. (2014) generates significant positive serial correlation in price but still far below the serial correlation seen in the data.

The positive serial correlation in 1–year price changes is particularly high during booms. Table 11.1 shows the price correlation when price growth is regressed on lagged price growth year by year. As Figure 11.4 also shows, the coefficient is over one at the height of the boom. This tendency of price growth to spiral is one of the most salient aspects of booms and one of the most difficult facts to reconcile with the simple models of housing price formation.

While housing prices show momentum at high frequencies, they mean revert at lower frequencies. Over 5–year periods, the correlation of price changes on lagged price changes ranges from -0.24 in the Sun Belt to -0.57 in coastal metropolises. Figures 11.1 and 11.2 show the extremely strong 5–year mean reversion over the last decade.

This mean reversion is reasonably compatible with rational models, even if the magnitude of changes during this particular period is not. The dynamic urban model of Glaeser et al. (2014) essentially predicts mean–reverting prices similar to those seen in the data. This price mean reversion is predicted both by mean–reverting income processes and by new construction.

11.3.3 Quantities versus prices

There are also significant facts about the quantities of housing that dynamic models need to explain. Quantities both have a purely physical component—the number of houses being produced—and a market–related component—the number of houses on the market at a given point in time. Housing supply–related experts tend to focus on the former numbers. Experts on search and market dynamics focus on the latter number.

The volatility of construction is significant, especially in the Sun Belt. The standard deviation of annual permits in Sun Belt metropolitan areas is over 5000 units. In coastal metropolitan areas, the standard deviation falls to under 2000 units. While these numbers are significant, they do not appear to be particularly high relative to the number predicted by reasonable estimates of housing supply functions and the volatility of local income changes.

Permitting behavior shows remarkable persistence at 1–year periods as well. The serial correlation of permits over 1–year periods is significantly over 0.5. Again, this is compatible with the predictions of a simple rational model. If the costs of building increase with the amount of buildings, then it is sensible for booms to persist over multiple years.

Table 11.1 Correlation price growth on lag of price growth

(1)	(2)	(3)	(4)	(5)	(6)
Year	Log growth from a year ago	Coefficient on lag growth	SE on lag growth	r^2	Observations
1980	−0.03	0.00	0.15	0.00	79
1981	−0.04	0.29	0.10	0.07	116
1982	−0.01	0.20	0.12	0.02	131
1983	−0.01	0.03	0.06	0.00	135
1984	−0.01	0.08	0.05	0.02	146
1985	0.00	0.37	0.05	0.24	168
1986	0.03	0.59	0.05	0.42	187
1987	0.02	0.81	0.05	0.55	214
1988	−0.01	0.78	0.06	0.42	238
1989	0.00	0.33	0.04	0.16	297
1990	0.00	0.34	0.06	0.10	236
1991	−0.01	0.11	0.04	0.02	337
1992	0.01	0.21	0.02	0.19	349
1993	0.00	0.68	0.04	0.41	359
1994	0.02	0.89	0.04	0.56	366
1995	0.00	1.14	0.05	0.54	381
1996	0.02	0.17	0.02	0.15	392
1997	0.00	0.52	0.05	0.20	396
1998	0.03	0.17	0.03	0.07	397
1999	0.01	0.46	0.04	0.21	397
2000	0.01	1.19	0.08	0.33	399
2001	0.04	0.57	0.03	0.41	399
2002	0.03	0.44	0.03	0.35	399
2003	0.03	1.10	0.04	0.70	400
2004	0.04	1.11	0.03	0.73	401
2005	0.06	1.48	0.04	0.74	401
2006	0.07	0.83	0.04	0.57	401
2007	0.01	0.02	0.02	0.00	401
2008	−0.05	0.52	0.07	0.13	401
2009	−0.04	1.22	0.04	0.69	401
2010	−0.08	0.33	0.02	0.43	401
2011	−0.06	0.54	0.02	0.54	401
2012	−0.03	0.58	0.04	0.36	401

Source: FHFA

For 5-year permitting periods, there is substantial mean reversion, which appears less compatible with a rational model. In a sense, this seems to reflect a pattern where periods of overbuilding are followed by periods of underbuilding. Perhaps, this represents an example of excessive exuberance in construction.
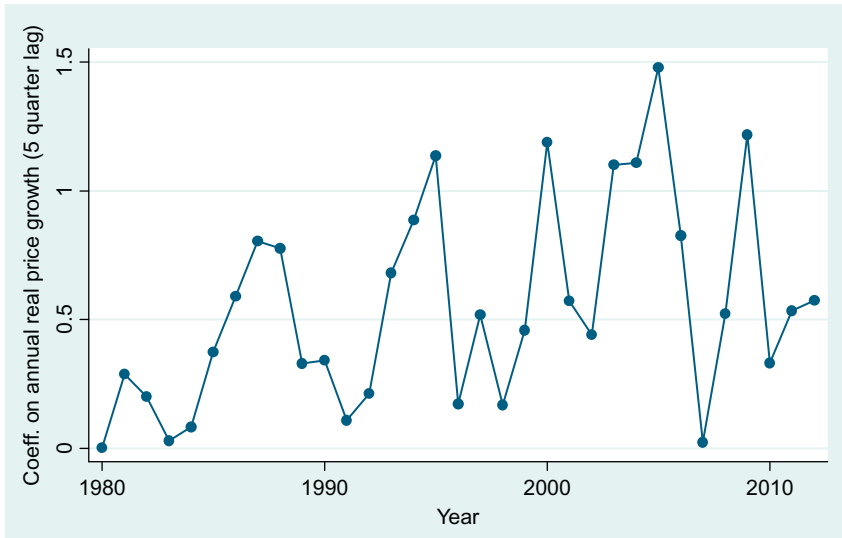
Figure 11.4 Real annual price growth on lag of real annual price growth. *Note: Dependent variable is first quarter annual growth. Source: FHFA.*

Head et al. (2014) also document that housing sales show significant persistence in the data. This is compatible with their model at 1-year frequencies, but there is too much sales persistence in the data, relative to their model, at longer frequencies.

Another particularly important stylized fact is the well-known relationship between sales volatility and price over the cycle. Markets are extremely active during booms and then dry up during busts. Some authors have interpreted this as evidence of nominal loss aversion on the part of sellers (Genesove and Mayer, 2001).

11.3.4 Bubbles in history

Given the rich history of real estate bubbles, it is useful to distinguish between two different classes of events: real estate fluctuations that are driven partially, at least initially, by new information coming from outside the real estate market itself and real estate fluctuations that appear to be driven primarily, sometimes almost exclusively, by events without the local housing market. Before 1980, real estate movements seem to have been typically associated with major uncertainty about external events.

The Chicago land boom of the 1830s, used by Shiller (2005) and others as an example of speculative mania, had a clear origin: the announcement that the state would fund a canal that would link the Great Lakes system with the Mississippi River system via the Chicago River. High cotton prices drove the Alabama boom of 1819 and high wheat prices helped justify Iowa land prices in 1910. In both cases, land buyers would eventually be burned, but price movements have justifications beyond merely the extrapolation of

price movements within the housing market itself. We aren't suggesting that these buyers were rational or that prices were themselves justified by fundamentals, but simply that these movements reflected more than buying based on past price movements.

By contrast, it is harder to see what external event could have motivated many of the price booms during the 2002–2006 period. The leading candidate is the proliferation of subprime technologies that expanded credit to low-income borrowers. This demand shock is not as clear as historic ones that involved the founding of cities. But Mian and Sufi (2009) presented evidence that less credit-worthy neighborhoods saw greater price increases during the boom. Investors may have had uncertainty about the long-run effects on housing demand of this credit expansion (Nathanson and Zwick, 2013).

Bubbles driven by exuberance about some external event can presumably take on any shape whatsoever, so long as prices eventually fall. A new announcement may spur an immediate price jump, which persists temporarily and then collapses, or the initial announcement may lead to ongoing price increases. An internally driven bubble must, however, display the positive serial correlation in price growth—the momentum that has come to almost define housing bubbles. The price growth itself is the news and the event that generates even more price growth. At the extreme, this creates the Alpine convex price pattern seen in places like Phoenix during the boom.

In this view, all bubbles are defined by large variance of price changes, relative to fundamentals and eventual mean reversion. Internally driven bubbles must also display positive serial correlation of price changes at higher frequencies. High levels of variance, positive serial correlation of price changes at high frequencies, and mean reversion at low frequencies are all well-known features of housing markets (Cutler et al., 1991; Glaeser et al., 2014). It is more debatable whether these features reflect the workings of bubbles or changes in fundamentals such as interest rates.

11.3.5 Directions for future research

These empirical regularities need further documentation and they suggest a host of other topics for study. Glaeser et al. (2014) is only one paper on excess variance in housing prices. More research is badly needed, comparing excess variance in housing with other asset classes. If this empirical regularity is confirmed, then bubble models have an added challenge: explaining why excess variance is less common in housing markets than elsewhere. One might have thought that the prevalence of amateur homebuyers would create more excess variance relative to professionally dominated asset markets. Perhaps, the limits on homebuyers' purchasing resources act as a brake on irrational exuberance. Nathanson and Zwick (2013) emphasized that the marginal buyer in housing is likely to come from the middle of a large distribution of beliefs and hence the most optimistic beliefs will not drive prices. In asset markets, one or two large optimists can dominate markets, which may explain the greater level of excess variance.

The shape of the cycle also needs more research. The US housing facts may have been exhaustively documented, but we could badly use more equivalent information about housing price series elsewhere in the world and on commercial prices. Glaeser et al. (2014) suggest that new supply plays only a modest role in explaining the mean reversion of prices, but that is an artifact of particularly restrictive assumptions. Further research on the role that new supply plays in bringing markets back to earth would be valuable.

The correlations across housing markets remain a good topic for future research. These connections not only help teach us about how bubbles work but also teach us about the appropriate homeownership policy for individuals. Housing is more of a hedge when markets are more closely correlated, since movers who have experienced housing price appreciation are more likely to experience higher housing costs in any new market as well.

The economic history of housing bubbles is also a promising area for future research. There is an abundance of qualitative efforts documenting the course of the events and pointing out the apparent folly of the buyers. More quantitative research is needed, especially if it can document the connection between the boom and the fundamentals of that era.

11.4. RATIONALIZING THE SEEMINGLY IRRATIONAL: SEARCH, HETEROGENEITY AND AGENCY PROBLEMS IN CREDIT MARKETS

We now turn to the economic approaches that have been used to help understand housing price movements that do not seem to be in line with the simple version of the LAPM discussed above. In this section, we discuss explanations that assume rational buyers. In the next section, we focus on less rational theories. We split these rational theories into three groups: "search, learning, and momentum," "changing credit conditions," and "rational bubbles and agency problems."

11.4.1 Search, learning, and momentum

We have already emphasized that housing markets are, in reality, highly decentralized markets with a great deal of heterogeneity. Search is a major feature of this market and there is no way that buyers or sellers can simply observe the current price of housing. Decentralization therefore is related to the level of information in the housing market, and those authors who suggest that features like momentum can represent learning are either implicitly or explicitly relying on the decentralization of the market. Several authors such as Wheaton (1990) and Krainer (2001) had shown that search and learning can help explain key features of housing price dynamics. Han and Strange (Chapter 13) surveyed the literature on search models in housing.

We will turn to limited information later, but even with perfect information, decentralized markets, especially when combined with some price stickiness, can lead to

staggered price responses to shocks which can create momentum in realized average prices. In Head et al. (2014), individuals enter into the housing market and choose whether to search for a home or just to rent. Some homeowners decide whether to sell or rent their houses. An increase in local area income causes an influx into the city. This influx causes a conversion of vacant homes to rental units, because matching renters is far easier than matching owners, and it also causes a gradual buildup in the number of would-be buyers, not all of whom are immediately matched with houses to buy.

This buildup of buyers causes market tightness to increase over time, which is also a feature of Genesove and Han (2012).[9] The rising number of buyers to sellers causes prices to increase even further. Eventually, new construction brings prices back down. This paper does an admirable job of fitting a number of features of the housing market, including patterns of sales and vacancies. But most notably, it manages to predict price momentum due to increasingly tight markets because of unmatched buyers.

Yet, this model does not really predict bubbles. It predicts that a positive shock might take several periods to work its way through the system, but not that the price movement might be many times greater than that implied by fundamentals. As such, this type of search model seems like it can clearly be part of the explanation for the structure of housing bubbles, especially their price momentum, but not for the bubbles themselves.

Guren (2014) provides an alternative search model that can also generate sticky adjustments to shocks. Guren (2014) assumes that sellers change their prices only every other period—there is an ad hoc stickiness in the model. As a result, only one-half of sellers change their prices during each period and the other half keeps their prices fixed. Sellers who price high, relative to the market, don't attract many searchers to their homes. This means that sellers are slow to react to upward demand shocks, because quick leaps to the equilibrium prices will make it hard to sell the property. The slow equilibration process can lead to momentum, even if there is perfect information about the state of demand.

There are limitations to the power of this type of argument. First, it is a better argument for upside momentum than downside momentum. Pricing high is particularly costly because it deters buyers from even visiting the house, but pricing low has no equivalent cost, which means that there is no strong force preventing sellers from quickly adjusting the prices downward.[10] Second, there is nothing in this argument that can lead to excess volatility, without some outside force such as exogenous beliefs. However, once there is an external forcing process creating excess volatility, as in Piazzesi and Schneider (2009), then a decentralized market can exacerbate the impact of that outside force.

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[9] In that paper, tightness overshoots, which amplifies the fundamental shocks.

[10] Novy-Marx (2009) provided a more symmetric amplification mechanism that operates through bargaining and the flow of entrants. This stimulating paper treats the flow of buyers as the primitive, rather than rents or the value of living in the locale. As such, it is hard to determine how these results relate to the excess variance that we are discussing here.

In these models, search primarily refers to matching the idiosyncratic features of the house with the tastes of idiosyncratic buyers, not learning about market fundamentals. Yet, it is surely true that buyers and sellers also gradually learn about market fundamentals through the search process. Even if they observe listed prices before the search process begins, search enables them to assess unit quality more thoroughly. Time spent on the market also acquaints buyers with actual sales prices for units that they have observed. This represents a form of learning about the state of the market.

There is ample evidence of ignorance and learning within housing markets. Clapp et al. (1995) provided evidence on the existence of various forms of rational learning. Levitt and Syverson (2008) illustrated that home sellers appear to be somewhat uninformed about the state of the market. Yet, while incorrect beliefs certainly have the power to move markets in many ways, it is unclear if rational learning can really generate particularly large movements in housing prices.

Rational learning suggests that buyers have formed some Bayesian estimate of the state of fundamentals and that estimate changes over time as new evidence trickles into the market. Generally, rational ignorance leads to less variance, not more, because individuals recognize how little they know. Shiller's (1981) variance bound test essentially lives off this point. Moreover, standard learning models still won't have predictable errors, so regular momentum or mean reversion in beliefs is incompatible with standard Bayesian learning.

To make this point precise, we return to the standard user cost argument in which P_t equals $R_t + \frac{E(P_{t+1})}{1+r}$. We assume that $r = 0$ and $R_t = 0$, so in this case, P_t equals $E_t(P_{t+1})$. It is impossible for anything known at time t to regularly predict the updating between t and $t+1$, so $\mathrm{Cov}(P_{t+1} - E_t(P_{t+1}), P_t - P_{t-1})$ must equal zero. This fact implies that highly rational learning on its own will not help us to understand momentum or mean reversion. Learning by individuals who are rational but ignorant seems unlikely to generate—on its own—any of the three salient features of price dynamics that we have discussed above.

This claim does not mean to suggest that semirational learning, employing rules of thumb (as in Shiller, 1999) or extrapolating, will not help explain housing price patterns. This seems quite likely, but we will address these issues later as we turn to less rational models.

11.4.2 Changes in credit conditions

Perhaps, the most popular "rational" model of housing price changes is that they reflect changing credit market conditions, which can mean low interest rates or permissive lending or both. Typically, some external factor, like a glut of Chinese savings, is justified to explain the credit market changes, which allegedly explain housing booms and busts. Yet, the common view that housing crisis was caused by subprime mortgages and a global lending glut has difficulty making sense of the heterogeneity across the US credit markets are

national or global, so if easy credit was the cause, then why did Houston experience almost no boom and bust while the cycle in Las Vegas was particularly dramatic? The heterogeneity across countries is also hard to explain if the boom is solely the result of a massive flood of global lending. These differences are also incompatible with a common, credit-caused demand shock interacting with heterogeneous supply (Davidoff, 2013).

Certainly, there is considerable evidence that easier credit did induce buying among subprime households in the years before 2007 (e.g., Mian and Sufi, 2009), and lower interest rates are generally associated with higher housing prices (e.g., Poterba, 1984). The rise of subprime lending certainly the boom establishes little about causality because the lending itself may be a reflection of overoptimistic beliefs, which are causing both phenomena.[11] Mian and Sufi's (2009) contribution is a tight focus on causal inference, which has considerably increased our confidence that subprime lending boosted prices, yet even in their work, subprime lending seems to only explain a modest fraction of the rise of housing prices.

Moreover, it is far from clear whether volatile interest rates can create massive housing price fluctuations in a purely rational model or at least a model without bubbles. We explore rational bubbles with overly cheap credit in the next section. Here, we briefly discuss the impact of credit market changes in the standard LAPM.

One standard version of the LAPM implies that $P_t = \frac{(1+r)R_t}{r-g_R}$ or price equals the $1+r$ times the flow value of housing divided by the difference between the interest rate and the growth rate of fundamentals. This formula would seem to imply an extremely tight relationship between prices and interest rates, especially in a high growth environment. This formula was used during the boom to justify extremely high prices.

But while this formula is correct in a static interest rate environment, it is not correct in a world in which interest rates are dynamic. For if interest rates mean revert, then buyers during periods when interest rates are low should expect to sell when interest rates are higher and vice versa. Rational expectations about the changing value of interest rates should cause buyers to be less responsive to changes in interest rates than a naive application of this formula would suggest.

Unfortunately, dynamic interest rate models do not yield easy closed-form solutions for housing prices, but Glaeser et al. (2013) simulated rational prices in a world in which interest rates followed a mean-reverting Cox–Ingersoll–Ross diffusion process. They found that the implied semielasticity of prices with respect to interest rates (the derivative of log prices with respect to a change in the interest rate) can drop by as much as two-thirds when the mean reversion of interest rates is taken into account. So, while the naive model predicts a relationship between interest rates and prices that is large enough to

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[11] A similar argument can be made about the correlation between investors buying homes and the boom (e.g., Haughwout et al., 2011). The investors seem more likely to be a reflection of market enthusiasm than to be an independent cause of rising prices.

explain much of the price increase between 2001 and 2006, a forward-looking model cannot. Moreover, the relationship between interest rates and prices implied by the forward-looking model does a better job of fitting the historical relationship between prices and rates over the long run.

There are at least three other theoretical forces that tend to reduce the connection between interest rates and housing prices. Elastic supply will tend to reduce any connection between demand-side forces, like credit conditions, and prices. The ability to refinance in the future will similarly make current conditions less important. Finally, if buyers discount the future using their own internal discount factor, rather than the market rate of interest, then that market rate of interest is predicted to have a smaller impact on price.

A final issue is the exact timing of interest rate changes over the period from 2003 to 2010. Prices continued to rise despite the slight rise in interest rates after 2004. Prices fell dramatically despite declining interest rates after 2007. The observed price changes can still be explained as reflecting changing credit market conditions, since interest rates do not reflect the probability of actually getting a loan. As discussed above, the global credit glut view also has difficulties explaining the heterogeneity within the United States and across the world.[12]

We do not mean to suggest that credit conditions are irrelevant in housing markets or in explaining bubbles, but simply that the relationship is not the simple one suggested by the LAPM. The LAPM is based on assumptions of rationality yet applying such a static model to a dynamic interest rate process assumes buyers are myopic, not rational. To provide an intellectually coherent framework, we must more fully embrace bounded rationality, and we will turn to that shortly.

Interest rates are only one aspect of credit markets. Mortgage approvals and down payment requirements may also shape housing price increases, and foreclosures may exacerbate housing price decreases. The simplest model for understanding why such credit conditions matter is to assume a variant of the LAPM with individual heterogeneity to allow for a downward sloping demand curve for housing. In such a model, the value of R_t differs by consumer and is denoted as $R_t(i)$, and consumers continue and are willing to spend as much as $\frac{(1+r)R_t(i)}{r-g_R}$. The consumers with the highest valuations will be inframarginal consumers, and we assume that there is a distribution $G(R_t)$ of these valuations across the set of feasible buyers. If N_S denotes the number of homes being sold and N_D denotes the number of potential buyers of whom only a fraction θ can manage financing, then N_S, the supply of homes, equals $(1-G(R_t^*))\theta N_D$, the demand for homes, where R_t^* reflects the valuation of the marginal buyer.

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[12] Mian and Sufi (2009) documented that the price boom was bigger in areas where credit seems to have been more constrained ex ante, which suggests that there is a geographic component of the easy credit hypothesis. Yet, that does not imply that this hypothesis can explain the large heterogeneity across metropolitan areas.

In this model, an increase in the availability of credit, captured by the parameter θ, will act to increase aggregate demand. The derivative of price with respect to θ is $\frac{(1-r)(1-G(R_t^*))}{(r-g_R)\theta g(R_t^*)}$, and the elasticity of price with respect to θ equals $\frac{1-G(R_t^*)}{R_t^* g(R_t^*)}$, which is exactly the same as the elasticity of price with respect to the number of potential buyers. In principle, this type of calculation can justify a robust relationship between approval rates and prices, just as the LAPM seems to justify a robust relationship between interest rates and prices, but some of the same issues arise. We are assuming a permanent change in approval rates, but periods of easy credit tend to be followed by periods of tight credit.

If approval rates rise temporarily, then buyers should expect future approval rates to fall. Buyers should anticipate this future drop, and this should cause buyers who expect to resell to become less sensitive to current credit availability. Mean reversion should likewise occur for down payment requirements and this will also dampen the connection between prices and credit market conditions. A fully specified dynamic model linking time-varying approval rates to housing prices has not yet been written, but it would be a worthy addition to the literature.

We have implicitly assumed that mortgage approval is unrelated to the individual's valuation of the house and that those who are denied credit are a random subsample of the buying population. That need not be the case. Individuals with financing may be richer and willing to pay more, or, conversely, individuals who were initially denied financing might be particularly eager to buy housing, perhaps because they are more risk-taking. One way to understand the striking findings of Mian and Sufi (2009) on the connection between subprime mortgage affordability and increased prices is that more lenient lending made it possible for high-risk, but highly optimistic, buyers to enter the market.

Stein (1995) provided an alternative mechanism through which credit markets influence price fluctuations. If individuals are largely credit-constrained, then a price movement upward creates significant capital gains for existing owners, which then enables them to purchase even larger houses. By contrast, a price drop will mean that these buyers are essentially locked into their existing homes and cannot buy elsewhere (Ferreira et al., 2010). There is a housing price multiplier because past housing price appreciation is providing the cash to fuel future housing price purchases.

While this section has focused primarily on the credit market causes of the price boom, there is also a significant literature connecting credit markets with the price bust and the adverse consequences of that bust. Perhaps, the most common idea is that housing busts generate defaults, and defaults then have adverse consequences on the health of the housing market. Palmer (2013) documented compellingly that the wave of defaults that followed the 2007 bust were the result of falling prices, not the composition of buyers who received credit immediately before the bust.

Campbell et al. (2011) documented both that forced sales, such as default, receive lower prices but that they also seem to lower the prices of nearby homes. Fisher et al.

(2013) found that the negative effect of condominium foreclosures on their neighbors seems localized to the particular address. Mian et al. (forthcoming) found that housing prices dropped more after 2007 in states that made it easier for lenders to foreclose on housing.

Why would defaults cause housing prices to drop? Guren and McQuade (2014) highlighted three effects: Distressed sellers tend to be more impatient and sell for less, buyers will become more choosy because they have more of a chance of interacting with a distressed seller, and homeowners who default are themselves priced out of the market. Taken altogether, they estimate that foreclosures may have exacerbated the price decline by as much as 50%.

Credit institutions may also impact the consequences of housing market downtowns. Somewhat obviously, the impact that housing busts have on financial institutions is due primarily to the fact that these institutions are providing credit for real estate investors, sometimes directly and sometimes by holding real estate-related securities, such as collateralized mortgage obligations. More subtly, housing prices appear to have a substantial wealth effect, and falling housing prices have led to substantial reductions in consumer spending and associated economic activity (Mian et al., 2013).

The compelling work of Mian and Sufi (2014) documents a wealth effect of housing that seems far stronger than the wealth effect of stock prices. Case et al. (2005) found a similar result. One explanation for this phenomenon is that stocks are owned by wealthier people who are not credit-constrained, while homes are owned by people who often are credit-constrained. Relaxing a credit constraint can easily have a far more powerful effect on spending than making an unconstrained individual wealthier, which may in turn explain why housing booms and busts appear to exert an outsized influence on the larger economy.

We now turn to rational bubble models in which credit market conditions can engender the possibility of dramatic price swings.

11.4.3 Agency, underpriced default options and rational bubbles

We have already discussed the two difficulties facing the models of rational bubbles in real estate: the standard violation of the transversality condition and the less standard problem of predicting an essentially unbounded supply of new housing. These difficulties become far less severe if homebuyers are charged too little for the possibility of defaulting on their mortgage.

We now more formally model the mortgage process so that buyers initially pay only a down payment fraction "d" of the purchase price of the house. At the end of the period, they either sell the house and repay the mortgage or default, and we assume that default carries a cost of "z" to capture the fact that many individuals fail to default even when that default would seem to be in their own interest:

$$R_t = dP_t - \beta E \text{Max} \left(P_{t+1} - (1+r)(1-d)P_{t'} - z \right), \tag{11.2}$$

where r is the market discount rate, possibly adjusted to address default risk. It is natural to assume that $\beta \leq \frac{1}{1+r}$, since homebuyers presumably always have the ability to earn the market rate by savings (or by just not borrowing money) but they can't always borrow freely and hence they may value future dollars at a rate above the market rate. To clarify issues, we assume that there is no uncertainty in R_t, so in the absence of bubbles, prices will remain fixed, so $P = \frac{R}{d(1-\beta)+\beta(1-d)r}$, which is the flow value divided by a weighted average of effective discount rates. The weights depend on the extent to which the loans are self-financed.

In this case, a deterministic bubble would satisfy

$$B_{t+1} = \left(\frac{d}{\beta} + (1+r)(1-d) \right) B_t, \tag{11.3}$$

where B_t denotes the "bubble" component of the price. This equation creates the same challenges involving the transversality condition and infinite housing supply. While deterministic bubbles don't seem to be feasible, stochastic bubbles can exist if they lead to default in negative states of the world. We consider a bubble with a value of B_t that takes on a value at $t+1$ of B_{t+1} with probability $1-\nu$ and 0 otherwise. We simplify by assuming that $P_F = \frac{R}{d(1-\beta)+\beta(1-d)r}$ is the fundamental value in all cases so that the price with the bubble equals $P_F + B_t$. We assume further that if the bubble bursts, the homebuyer defaults. The technical condition for this to be optimal is that $P_F(d(1+r)-r)+z < B_t$. The equilibrium condition for a stochastic bubble is that

$$B_{t+1} = \frac{(d+(1-\nu)\beta(r-d(1+r)))P_F - R + \nu\beta z + (d+(1-\nu)\beta(1+r)(1-d))B_t}{(1-\nu)\beta}. \tag{11.4}$$

In the extreme case where $P_F = R = z = 0$, so the bubble alone remains, this simplifies to

$$B_{t+1} = \frac{d+(1-\nu)(1-d)(1+r)\beta}{(1-\nu)\beta} B_t \tag{11.4'}$$

The bubble's value increases but only if it fails to burst, that is, with probability $1-\nu$, hence, the discounted value at time $t+j$ equals $B_t(d+(1-d)(1-\nu)(1+r)\beta)^{t+j}$. If $(1-\nu)(1+r)\beta = 1$, so that the interest rates are set so that the discounted expected value of a loan of one dollar is equal to one, then $\frac{B_t}{(1-\nu)\beta} = B_{t+1}$ or so $B_t = \beta^j E(B_{t+j})$ bubble maintains its expected value.

The standard transversality condition is that $\lim_{j\to\infty} \beta^j E(B_{t+j}) = 0$, and so this structure violates this condition. As the transversality condition holds for the fundamental part of the housing value, violating the transversality condition implies that people expect that in the long run, the bubble component alone will determine the home's value. Diba and Grossman (1988) argued that such explosive behavior implies that rational bubbles are

impossible, especially when assets can be supplied into the market. Santos and Woodford (1997) similarly suggested that the conditions that admit bubbles are "fragile."[13] Influenced by these papers, we also believe that rational bubbles seem implausible when they imply extraordinarily high future housing values.[14]

Bubbles become far more plausible if lenders underprice default risk, which might reflect agency problems with banks or irrationality by lenders. If interest rates are set too low, so that $1 > d + (1-d)(1-v)(1+r)\beta$, then lenders aren't fully compensated for the threat of default. In this case, the expected value of the bubble decreases over time and the transversality condition is not violated. Housing prices will rise with the bubble, but the rises may be less extreme. Still, there is a nonzero probability that housing prices will become extremely high and this should predict an enormous supply response.

There are conceivable ways of salvaging the model with endogenous supply. Perhaps, builders are sufficiently risk-averse, and it takes enough to build so that anticipating the possibility of a burst necessarily leads to limited production. This would be most plausible if v is high so that the probability of default is quite high. Still, the fact remains that construction was extremely high in Phoenix, Las Vegas, and Miami during the recent boom, which makes the case for this type of rational bubble model more difficult to make.

Moreover, since a fully priced risk would require the bubble to rise quickly enough to violate the transversality condition, this finite price bubble requires the underpricing of risk. This underpricing does seem to be a regular feature of booms, but why does it occur? One explanation is that lenders are irrational, for some reason, but that violates the spirit of this section, which is to explain real estate bubbles with rational models.

The alternative explanation, which has been offered by many observers, is that there is an agency problem within the lending sector (Green, 2008; Diamond and Rajan, 2009), perhaps because of federal deposit insurance (Demsetz et al., 1997). In principle, this could occur within banks themselves even if those banks have no deposit insurance and hold mortgages on their own balance sheets. The CEO hires agents to make loans at an appropriate interest rate. Their compensation is increasing with the number of loans or the average interest rate paid, but limited liability precludes severe punishment in the state of the world when the bubble bursts. The result is that agents compete and the market rate of interest charges too little for default risk. Pavlov and Wachter (2006) argued that if some bankers are underpricing default risk, competition may push all bankers to underprice default risk.

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[13] These arguments are different than the alternative view that bubbles cannot exist because they will be arbitraged away. Abreu and Brunnermeier (2003) made a compelling case that this is unlikely in financial markets and the power of arbitrage is even weaker in housing.

[14] Kivedal (2013) found evidence for the existence of a bubble in the housing market between 2000 and 2013 but concluded that it is more likely to be irrational than rational. Giglio et al. (2014) rejected infinitely lived bubbles in the United Kingdom and Singapore by comparing very long-run housing rental contracts to infinite ownership rights.

The larger debate over agency risk in lending concerns the creation of mortgage-backed securities. In this version of the hypothesis, mortgage originators have little incentive to screen for risk because they pass those risks downstream to the eventual security holder who has little ability to appropriately learn the truth. The presence of mortgage insurers, such as Fannie Mae and Freddie Mac, further decreases the incentive to price appropriately for risk. Purnanandam (2011), for example, found that banks that originated loans primarily to distribute them to downstream investors generated "excessively poor quality mortgages." Piskorski et al. (2010) found a link between securitization and default, which Adelino et al. (2010) hotly disputed.[15]

Of course, this type of model still raises questions. If the risk comes from a systemic bubble, rather than idiosyncratic risk, then investors should be able to understand that they are subsidizing the homebuyers. The nature of the rational bubble is that its features are widely known and homebuyers supposedly understand the risks perfectly. If they understand the risks, then so should the ultimate investors. Agency problems typically occur when there is local information that can't be observed by the principal, but there is nothing local about a system-wide bubble.

Perhaps, the best explanation for why systemic risk might be subsidized is that the government is bearing the tail risk. If the public sector is bearing the tail risk for political reasons, then this still could lead to underpriced default risk that encourages the emergence of rational bubbles. Nonetheless, this theory would still have to explain why private mortgage insurers led the way into the subprime lending that would be at most risk from a bubble bursting.

A slightly different alternative to this purely qualitative rational bubble model is to use the option pricing model of Krainer et al. (2009) and ask, as in Glaeser (2013), how much housing prices would increase if borrowers were given an non-priced default option. The model requires a switch to continuous time, so we must assume that the flow value of the house equals $r(t)$, where r follows a geometric Brownian motion. The drift is g_R; the variance is σ^2. Individuals discount at a rate but pay in interest on their mortgage each period or r times the outstanding debt or $r(1-d)P$, where P refers to the initial purchase price. The borrowers are only paying the interest on the mortgage. We assume costless default and the purchase price of the house will then satisfy

$$P_t = \frac{\rho}{\rho d + r(1-d)} \left(\frac{z^z (\rho - g_R)^z (r(1-d)P_t)^{1+z}}{\rho^{1+z}} R_t^{-z} + \frac{R_t}{\rho - g_R} \right), \qquad (11.5)$$

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[15] Piskorski et al. (2010) found that securitized loans are more likely to be foreclosed and less likely to resume making payments, suggesting that renegotiation may be less likely with securitized loans, perhaps because of agency problems. Adelino et al. (2010) found little evidence of renegotiation in nonsecuritized or securitized loans and no difference in loan modification between the two samples.

where $z = \frac{g_R - 0.5\sigma^2 + \sqrt{(g_R - 0.5\sigma^2)^2 + 2\sigma^2\rho}}{\sigma^2}$. The first term in brackets represents the value of the default option; the second term reflects the value of the house without any possibility of defaulting. By calibrating the model, Glaeser (2013) estimated just how much an unpriced default option could contribute to higher housing prices during historic booms. This approach assumes that the market rate and the private discount rate are the same and then calculates the value of the first term in the expression. Typically, this represents less than 17% of the price for more recent price swings, which is surely an overestimate since it assumes that interest rates incorporated none of the cost of potential default.

This calculation again illustrates that if credit markets are responsible for the extreme volatility of housing bubbles, then it seems more likely they do so by making conditions ripe for bubbles. This view suggests that there is not an automatic link between housing prices and easy credit, but rather that easy credit is a necessary—but not sufficient—cause of extreme price volatility.

11.4.4 Directions for future research

All of the topics discussed above contain major open questions. Search in housing is currently a hot topic, and recent papers have yielded promising results. Yet, we are still unsure whether some form of essentially rational search model can deliver all of the stylized facts discussed in Section 11.3. It is clear that these models can deliver momentum, but excess variance does not spring so readily from such models. Moreover, it is yet to be seen whether these models can explain the cross-sectional variation in housing market behavior.

The role of credit markets in housing cycles is also far from settled. Indeed, the best interpretation of Glaeser et al. (2013) is not that easy credit didn't cause the cycle, but that the confident view that it did cause the cycle has little solid support. More empirical work is surely needed, especially taking advantage of international data where they might be usable independent variations in credit conditions. More theory is also needed, particularly analyzing the role of credit in near-rational models.

The connection between bubbles and underpriced default risk is sketched here, but a full treatment of that topic would also be useful. Is it really plausible that agency problems could, with no irrationality, generate underpriced default risk that is large enough to produce large rational bubbles? Can such a model deliver other predictions that could be tested?

11.5. A MENAGERIE OF MODEST MADNESS: BOUNDED RATIONALITY AND HOUSING MARKETS

We now turn to less than rational models that have also been used to investigate real estate fluctuation, and typically, those models involve buyers who hold excessively optimistic

beliefs about future housing price growth. The Case and Shiller surveys of recent buyers suggest that such beliefs certainly exist. For example, Case and Shiller (2003) reported that buyers in Orange County, California, in 1988 expected prices to rise by 14.3% per year over the next 10 years, and in 2003, they expected prices to rise by 13.1% annually over the next 10 years. Case et al. (2012) reported that expected price growth over the next 10 years from buyers in Middlesex County, Massachusetts, fell from 10.6% in 2004 to 3.1% in 2012.

These striking survey results need a grain of salt, for they are surely muddled by innumeracy and wishful thinking. Yet, even if the numbers appear excessive, they surely capture an important reality. Many buyers during booms seem to have expectations that are wildly optimistic and often at odds with the views of economists and the experience of longer-term price trends.

We begin this section with exogenous belief models, in which individuals for some reason have beliefs that are unduly optimistic. As models in which beliefs are entirely flexible and determined outside of the model have the potential to "explain" any housing event, they are not particularly compelling as theories without some added ingredient. Exogenous belief models are typically used to illustrate some other point about housing markets, such as the role of search or endogenous housing supply. The second class of models that we consider are extrapolative beliefs, and we consider both a naive version where extrapolation is merely assumed and a more sophisticated version in which extrapolation emerges out of cognitive limitations. We then turn to the broad class of models with cognitive limitations that involve shorter time horizons and simple models of housing price formation. We end with a discussion of social learning.

11.5.1 Exogenous and heterogeneous beliefs: search, endogenous housing supply, and land acquisition

The simplest way to get a bubble is just to assume that individuals are unduly optimistic. Using the standard pricing formula where P_t equals $R_t + \beta E(P_{t+1})$, we can justify almost any price process imaginable by assuming differential values for $E(P_{t+1})$. Similarly, if pricing follows a growth formula like $P_t = \frac{R_t}{1-(1+g_R)\beta}$, then exogenous changes in the belief about future rent growth will naturally cause fluctuation in the price and anything is possible. Since anything is possible, the exogenous optimism model on its own essentially fails as social science, for it cannot be rejected by the data, and a model that cannot be rejected cannot be tested. Essentially, in the move from perfect rationality to exogenous beliefs, we have moved from a theory with predictions that are too narrow to a theory that has predictions that are too broad. If we believe that beliefs are not perfectly rational, and we want to test that hypothesis, then we must assume a particular structure for beliefs that can be tested.

While the assumption of exogenous beliefs cannot be tested on its own, it does provide testable implications when nested in a larger model. Two examples of this structure

are Glaeser et al. (2008) and Nathanson and Zwick (2013). Glaeser et al. (2008) assumed that bubbles are generated by random increases in the buyers' valuation of homes. They examined how this exogenous shift in demand interacts with supply.

During a boom, holding the degree of irrational surge constant, places with more inelastic supply will have greater increases in price and lower increases in quantity. This claim merely makes the point that the logic of Economics 101 continues to operate even if the demand curve is being shifted by irrationality. This point follows Becker (1962). After the bubble, the impact of supply elasticity is ambiguous. If supply is extremely inelastic, then the bubble will have had no impact on quantity during the boom and hence little impact on prices after the boom is over. This may reflect the reality of northern California or Massachusetts. In extremely elastic places, bubbles cause explosions in homebuilding, but the elasticity of housing supply itself mutes the impact of overbuilding ex post, as long as the area continues to build at all.

Nathanson and Zwick (2013) also explore exogenous belief shifts, but their focus is on heterogeneity. They assumed that individual investors have different prior beliefs about the value of real estate in a different area. They ruled out the possibility that beliefs will converge through a learning process. Optimists buy up all the land and the rental housing. But owner-occupied housing stays dispersed among residents of all beliefs because some residents prefer owning over renting, and they have diminishing marginal utility of housing. Optimistic beliefs influence house prices most in areas with ample land or rental housing. Prices are less prone to bursts of extreme optimism in housing markets that only have owner-occupied housing and no undeveloped land.

This observation explains why many elastic areas, which are those with undeveloped land, have such large house price booms. Nathanson and Zwick (2013) show that land price increases capture nearly 100% of the dispersion in house price increases across metro areas. Furthermore, several US public homebuilders acted like speculators by taking large positions in the land market between 2001 and 2006 and then suffering large capital losses. Short selling of homebuilder stock rose dramatically during this period, providing evidence of pessimists who disagreed with the homebuilders' high valuations of land.

11.5.2 Extrapolative beliefs

Perhaps, the most popular alternative to rationality in housing markets (and perhaps finance as well) is extrapolation, occasionally called momentum trading or backward-looking investment. Clapp and Tirtiroglu (1994) is an early example of this assumption in housing economics. In the real estate context, Glaeser (2013) referred to extrapolators as Gordonians because of their blind use of the Gordon growth formula. The principle is simply that investors use a formula like $P_t = \frac{R_t}{1-(1+g_R)\beta}$, and they use the recent growth rate in past prices to infer the growth rate in fundamentals. There are two ways of generating this type of behavior. One option is to assume that these erroneous beliefs arrive

exogenously in a small share of the population. A second option is to derive these beliefs as the result of primitives.

The choice between these two options is somewhat connected to the decision about whether to assume that the extrapolative bias is ubiquitous or particular to a few odd eggs. Finance has a tradition going back to DeLong et al. (1990) of assuming that irrationality is limited to a small share of the market and then looking at what impact this irrationality would have on market-wide prices. The appeal of this approach is that irrationality can be assumed for only a few, preserving the possibility that most of us are rational.

Barberis et al. (2015) documented how a small number of extrapolative buyers can move prices in financial markets. Piazzesi and Schneider (2009) provided an elegant example of this tradition transplanted into housing markets, which makes the point that if there is only a modest share of the stock of renters with extrapolative beliefs, that small share of the stock can become a large share of the flow of new home purchases, since the flow of purchases is only a small share of the stock.

Guren (2014) follows a similar tack of examining the impact of a minority of backward-looking investors (i.e., extrapolators) in his model of search and slightly sticky prices. He finds that his model also exacerbates the power of a small amount of irrationality, allowing it to propagate throughout the system. In particular, small numbers of extrapolators create significant positive serial correlation in housing prices.

While Piazzesi and Schneider (2009) did persuasively show that a small number of optimistic buyers can make a boom, we think that the 2002–2006 boom is best seen as a far more widespread burst of optimism. We agree that boom-level prices may not have reflected the majority opinion and surely did not reflect the views of a sizable minority of housing market skeptics. Yet, millions of Americans thought that these high prices made enough sense to purchase houses. Perhaps, these homebuyers were extrapolating recent price increases, or perhaps, they were passive and not evaluating house prices carefully because of long horizons. The available survey data (Case et al., 2012) suggest that optimistic beliefs were ubiquitous among buyers during the boom period, although that comes with the usual caveats on survey data.

A moderate deviation from strict rationality can take the form of either large deviations from rationality for a small number of people or small deviations from rationality for much larger groups. While some economists may be comfortable just assuming that large numbers of homebuyers follow ad hoc extrapolative beliefs, we prefer assuming smaller deviations from rationality since these deviations must apply to such a large number of homebuyers.

One means of microfounding extrapolative beliefs is to assume that investors are unsure about the growth rate in the fundamental. We illustrate our point with a particularly simple model in which $R_t = R_{t-1} + g_R$. The correct pricing formula satisfies $P_t = R_t + \beta P_{t+1}$. The correct pricing formula is that $P_t = \frac{R_t}{1-\beta} + \frac{\beta E_t(g_R)}{(1-\beta)^2}$. At all points of t, individuals observe R_t, but they will not observe past values of R and will only observe the past two values of P_t.

At time zero, individuals know R_0, but have no information about the growth rate and use their prior belief, $g_R = 0$, in their pricing. Hence, the price at time 0 equals $\frac{R_0}{1-\beta}$. At time one, new buyers emerge who observe R_1 and P_0. If they are rational, then they can readily uncover the true value of g_R, which equals $R_1 - (1-\beta)P_0$. The new price equals $\frac{R_1}{(1-\beta)^2} - \frac{\beta P_0}{1-\beta}$, which is completely rational. The heavy weight given to R_1 reflects its double role in determining the flow of welfare associated with the house and also in determining the growth rate of that flow.

At time 2, if buyers are sophisticated, they can look at prices at time zero and time one and we now turn to the price at time 2. If time 2 buyers were sophisticated, $t+2$. If these buyers were sophisticated, they would look at prices at time zero and time one, and the correct pricing formula would be

$$P_2 = \frac{R_2}{1-\beta} + \beta(P_1 - P_0) = P_1 + (1-\beta)(P_1 - P_0). \tag{11.6}$$

There would be momentum but only because there is a persistent growth rate. The prices would not be growing up any faster than that fixed growth rate.

However, assume that these buyers were less sophisticated. They follow a rule-of-thumb assumption that prices at all times reflect the same assumption about growth rates, since growth rates are not changing. Since they do not observe the growth rate, they cannot directly infer the past levels of R but instead use the single change in P that they observe to infer a growth rate. They believe that $P_{t+1} - P_t$ equals $\frac{R_{t+1} - R_t}{1-\beta}$ or $\frac{g_R}{1-\beta}$. Hence, the price at time t will equal $\frac{R_t}{1-\beta} + \frac{\beta(P_{t-1} - P_{t-2})}{1-\beta}$. This implies

$$P_2 = \frac{R_2}{1-\beta} + \frac{\beta(P_1 - P_0)}{1-\beta} = P_1 + \left(1 - \beta + \frac{\beta^2}{1-\beta}\right)(P_1 - P_0). \tag{11.6'}$$

The level of momentum has increased, perhaps dramatically, because the growth rate is being inferred from the change in prices, which themselves already included changing expectations about the growth rate.

In essence, these buyers are cursed in the phrase of Eyster and Rabin (2005), which means that individuals mistakenly believe that "other players' actions depend less on their types than they actually do." Eyster and Rabin's (2005) idea is that it is difficult to fully infer the motives of others, and as a result, we don't always make sense of market outcomes. For example, to avoid the winner's curse, bidders must understand that if others bid less, then they must have worse signals about the value of the good being sold. Individuals will take bets when they shouldn't because they don't recognize that an individual who offers to bet with them is implicitly signaling some private information.

Glaeser and Nathanson develop a more sophisticated version of this approach in which growth rates are stochastic, and past prices are informative about the current rate of fundamental growth. The critical weakness again that delivers extrapolation, and

hence positive serial correlation, is that homebuyers believe that past price movements reflect changes in fundamentals, rather than changes in beliefs about the growth rate.

11.5.3 Cognitive limitations: natural expectations, spatial benchmarking, and rule-of-thumb spending

That particular model is part of a general class of models of cognitive limitations, many of which have the potential to add to our understanding of real estate fluctuations. Shiller (1999) reviewed many of the standard behavioral tics, which may influence housing markets. The intellectual challenge is that there are so many potential, plausible cognitive limitations that it is hard to naturally focus on any particular one. We will discuss several types of cognitive limitation here, and the extrapolation discussed above can also be seen as one example of cognitive limitation: the inability to think through how other people think.

Fuster et al. (2010) offered one particular form of cognitive limitation that they title natural expectations. Natural expectations models require agents to make predictions using only an excessively parsimonious model. For example, if the true R_t process was described as $R_t - R_{t-1} = B_1(R_{t-1} - R_{t-2}) - B_2(R_{t-2} - R_{t-3}) + \epsilon_t$, then the agents might attempt to estimate the regression by fitting only $R_t - R_{t-1} = \hat{B}_1(R_{t-1} - R_{t-2}) + \epsilon_t$. This obviously has the capacity to create mistakes, but it does naturally generate excess volatility or strong one-period price momentum.

If homebuyers have rational expectations, then applying the usual pricing formula $(P_t = R_t + \frac{1}{1+r}E(P_{t+1}))$ implies

$$P_t = \frac{(1+r)^3 R_t - (1+r)((1+r)B_1 - rB_2)R_{t-1} - (1+r)^2 B_2 R_{t-2}}{r(1+r)(1+r-B_1) - rB_2}. \tag{11.7}$$

Homebuyers with natural expectations would set

$$P_t = \frac{(1+r)^2 R_t - (1+r)\hat{B}_1 R_{t-1}}{r(1+r-\hat{B}_1)}. \tag{11.7'}$$

In Table 11.2, we simulate the impact of these beliefs assuming that $B_1 = \hat{B}_1 = 0.9$, $B_2 = 0.8$, and that $B_1 = \hat{B}_1 = 0.5$, $B_2 = 0.3$. The interest rate is 0.04 and the standard deviation of the shock is $1000. We do not believe that these parameter choices are realistic. They are instead chosen to illustrate what is necessary for natural expectations to deliver high degrees of momentum and excess volatility. The medium persistence case still has considerably more momentum than either income or rents. In that case, the volatility is slightly increased by moving from rational to natural expectations. There is considerably more mean reversion with natural expectations, because the buyers do not realize that positive shocks today will lead to negative shocks in two periods. However, this does not generate significant price momentum. Since even the natural expectations

Table 11.2 Fixed supply model

(1)	(2)	(3)	(4)	(5)
	Medium persistence		High persistence	
Horizon	Rational	Projection	Rational	Projection
Price change volatility				
1 year	32,600	52,800	29,800	349,000
3 years	56,700	86,000	51,300	649,000
5 years	72,900	94,000	65,000	434,600
Price change serial correlation				
1 year	0.01	0.05	0.01	0.35
3 years	−0.01	−0.34	−0.04	−0.85
5 years	0.00	0.20	0.00	−0.20

agents recognize that a shock today will become a shock tomorrow, this positive effect is built immediately into prices and this means that there is little extra momentum created by this cognitive limitation.

In the truly extreme case of massive short-run persistence and massive medium-run mean reversion, we do indeed get momentum in prices with natural expectations but not with rational expectations. The rational expectations agents understand that a positive shock today will be offset soon and, as a result, prices move far less. The natural expectations agents have much more severe price movements and significant momentum. This momentum turns into mean reversion when the true nature of the process inserts itself. Of course, these natural expectations agents are making mistakes on a massive scale with some degree of regularity, which may be difficult for many economists to accept. We find this exercise interesting but believe that the assumptions needed for natural expectations to fit the housing price data are just too extreme.

One particularly important use of natural expectations, however, is that they may explain why homebuyers so often appear to miss the power of supply to bring prices back down to earth. If it always takes time to build new housing units, then making predictions based on short time periods will always mean missing the power of supply. This will mean that natural expectations will typically lead to a demand-side analysis only and lead buyers to fail to predict that supply will eventually cause prices to converge.

To illustrate this point, we assume that $R_t = \theta_t - \alpha N_t$, where θ_t is the exogenous demand shock and N_t reflects the supply of new housing. We assume that $\theta_{t+1} - \theta_t = \delta + \rho(\theta_t - \theta_{t-1} - \delta) + \varepsilon_{t+1}$, so the true process is indeed a one-period moving average. We allow a two-period production process $E_t(P_{t+2}) = c_0 + c_1 I_{t+1}$ and $N_{t+1} = N_t + I_t$. This means that the production decision that determines the stock at $t+2$ is made with the information available as of time t.

Table 11.3 Variable supply with low construction costs

(1)	(2)	(3)	(4)	(5)	(6)
		$\tilde{I}=I_t$		$\tilde{I}=I_{t-1}$	
Horizon	Full rational	Semi	Rational	Semi	Rational
Price change volatility					
1 year	6000	50,400	51,300	51,600	52,500
3 years	9700	50,500	51,300	73,000	74,300
5 years	11,300	50,700	51,300	73,000	74,300
Construction correlation					
1 year	5500	2000	2000	2000	2000
3 years	14,600	5900	6000	5900	6000
5 years	22,300	9600	9800	9600	9800
Construction serial correlation					
1 year	0.75	0.96	0.96	0.96	0.96
3 years	0.55	0.92	0.92	0.92	0.92
5 years	0.41	0.88	0.87	0.88	0.87

We consider three possibilities. First, it is possible that both the homebuyers and the homebuilders are completely rational. This is the case shown in the first column of Table 11.3. In this case, there is modest volatility, significant mean reversion, and little price momentum. Buyers anticipate all the future changes, but it remains true that a new building causes initial shocks to disappear over time.

In all cases, we allow the homeowners to correctly understand the dynamics of demand but not to fully understand the dynamics of supply. In both of our semirational cases, we assume that homebuyers believe that supply is fixed. In columns (2) and (3), buyers believe that supply is fixed at the current rate of supply. In columns (4) and (5), buyers believe that supply will be fixed at the level supplied next period. We also have two possibilities for the degree of rationality about homebuilders. In columns (2) and (4), homebuilders choose I_{t+1}, assuming that $I_{t+1}=I_{t+2}$. In columns (3) and (5), builders are completely rational.

In all cases, these near–rational assumptions fail to deliver any price momentum. The failure to anticipate supply responses just does not deliver a reason for price growth to follow price growth. There is momentum in the demand fundamentals, but the natural expectations buyers build that into their period t prices. However, the buyers' limited ability to anticipate supply does exacerbate price volatility and price mean reversion. The price volatility is higher because they do not anticipate the fact that rents will be declining over time as new supply enters into the market. Mean reversion is higher because prices rise more initially but then come back down to earth quickly.

Somewhat surprisingly to us, this semirationality reduces the volatility of construction changes. As prices move around a great deal, construction moves less. A second less studied form of cognitive limitation is spatial benchmarking. This rule of thumb takes the spatial equilibrium logic of the Alonso–Muth–Mills model and the Rosen–Roback model and applies it to prices, rather than rents. This type of logic was used historically to convince investors in the wisdom of Los Angeles real estate prices during the boom of the 1880s, and it is compatible with the Ferreira and Gyourko (2012) evidence on the spatial spread of the boom during the last decade.

This logic will be particularly problematic if there are supply differences across areas. To consider an extreme example, assume that in city A (Los Angeles), the supply is fixed and $R_{t+j} = e^{gj} R_t$, so the benefits are deterministically growing. Applying the pricing formula $P_t = \int_{j=0}^{\infty} e^{-rj} R_{t+j} dj$ implies that prices in city A should equal $P_t = \frac{R_t}{r-g}$.

Assume that at a point in time, city B yields benefits $R_t - \delta$. Naive spatial extrapolation would then imply that the price in city B should equal $\frac{R_t - \delta}{r-g}$ and this would indeed be rational if prices in city B were also increasing at the rate g. One reason why the formula might be radically wrong is that the growth rates differ in the two areas. In that case, static comparisons would lead to incorrect pricing.

A less obvious source of error can come from ignoring supply conditions across the two areas. To focus on that possibility, we assume that $g = 0$ and R_t is fixed at R_A in city A. The fixed flow of utility reflects the assumption that supply in city A is also fixed. Prices in city A should equal $\frac{R_A}{r}$.

In city B, $R_t = \theta_B - \alpha N_t$, so the flow utility is falling with the number of people living in the city, perhaps because of congestion. At time zero, $\theta_B - \alpha N_0 = R_A$, so initially the two places yield comparable returns. Hence, naive spatial extrapolation implies that the price in both cities will equal $\frac{R_A}{r}$. This will differ from the rational price because individuals should expect the impact of new supply. The cost of supplying new homes is increasing linearly in the number of new homes, so that the price must equal $c_0 + c_1 \dot{N}$, whenever new homes are being built. We assume $\frac{R_A}{1-\beta} > c_0$ to ensure that new construction always occurs.

The rational pricing and growth equations in city B satisfy

$$\dot{N} = \left(\frac{\theta_B - \alpha N_0}{r} - c_0 \right) \frac{r(r + c_1)}{c_1 r(r + c_1) + \alpha} e^{-c_1 t} \tag{11.8}$$

and

$$P = c_0 + \left(\frac{\theta_B - \alpha N_0}{r} - c_0 \right) \frac{c_1 r(r + c_1)}{c_1 r(r + c_1) + \alpha} e^{-c_1 t}. \tag{11.9}$$

Even at time zero, the rational price in city B will equal $\frac{\alpha c_0}{c_1 r(r + c_1) + \alpha} + \left(\frac{\theta_B - \alpha N_0}{r} \right) \frac{c_1 r(r + c_1)}{c_1 r(r + c_1) + \alpha}$, which must be less than $\frac{R_A}{r}$, the naive spatial expectations price. Naive buyers in city B are comparing their city with city A, perhaps like buyers in Las Vegas in 2005 comparing

their city with Los Angeles. They see comparable flow utility in the two cities, which suggests to them, naively, that the prices should be comparable. Yet, sophisticated buyers understand that city B will add housing over time, which will cause flow utility to fall, and that city B housing should therefore cost less than city A.

If individuals in city B persist in using the pricing formula that is appropriate for city A, so that prices equal $\frac{\theta_B - \alpha N_t}{r}$, then $\dot{N} = \frac{1}{c_1}\left(\frac{\theta_B - \alpha N_t}{r} - c_0\right)$, which will initially be larger than under rational pricing. This will lead to overbuilding in the short run, and eventually, prices will lie below their level under rational pricing. The rents in the two cities will start at the same level, but they will soon differ because of excess supply, and initially, prices should reflect this expected convergence.

A third way in which prices may diverge from rationality is that buyers follow other prescribed rules of thumb. Some options that have been discussed are always spending as much as they can afford, given current interest rates. If the marginal homebuyer has an income of Y dollars and is able to get a no-down payment mortgage, then the maximum willingness to pay is some fixed fraction times Y divided by the interest rate. This rule of thumb suggests a high elasticity of price with respect to interest rates but one that is no different than in the standard model. It also suggests that the price of housing will be decoupled from the benefits of housing, which does run counter to centuries of economic thinking. Money illusion can also contribute to "housing frenzies" if buyers overestimate the future costs of real interest payments when inflation is high and will then bid more for housing as inflation drops (Brunnermeier and Julliard, 2008).

One added possibility is that individuals hop from one type of belief formation to another. For example, they may sometimes be rational but become adaptive during periods of sustained growth. Alternatively, they may just ignore future price appreciation much of the time during periods when such appreciation seems unlikely or is just salient. During those periods, prices track rents, but if an event makes the prospect housing price appreciation salient, then buyers start making potentially biased forecasts about future housing price growth.

11.5.4 Social learning and the entrepreneurs of error

The previous section focused on learning from past price movements, but there are many other influences that shape individuals' beliefs about housing prices. Perhaps, the most pervasive and important source of information that humans rely upon is the statements of people around us. Most of the time, these social influences are relatively benign, but in some cases, these influences may reflect private motives at odds with the individuals' own best motives.

The early literature on manias emphasized the rational causes of imitation. Froot et al. (1992), for example, emphasized the strong incentives of investors with short horizons to focus on the same sources of information. Bikhchandani et al. (1998) and Banerjee (1992)

both presented models of information cascades, where individuals rationally imitate one another. DeCoster and Strange (2012) applied this logic to developers, who imitate one another because they assume that their peers have made their decisions based on valuable information about the state of the world. The result can be a glut of overbuilding.

These forces will only become more powerful if the urge to imitate exceeds the purely rational. One natural version of this is to again assume a type of "cursed" behavior, where individuals underestimate the social causes of the behavior of others. In this case, each new buyer infers that the mass of preceding buyers is acting on private information, rather than just following the leader. In this case, each new buyer believes that the actions of the herd contain an extraordinary rich amount of information, whereas in reality, the mob might just be following the leader of a single person. This type of incorrect inference will tend to make herd behavior extremely powerful and manias extremely common.

While DeCoster and Strange emphasized builders' decisions, this same logic could relate to buying homes in a particular locale, such as Las Vegas in 2005. According to this view, the large number of Las Vegas buyers provides evidence to new buyers that Las Vegas is an excellent investment. This logic then encourages an even larger rush of buyers.

The literature has expanded beyond imitating actions to following advice. One notable paper in this genre is Hong et al. (2008), which argues that interested advisors may play an important role in encouraging the role of bubbles. According to this view, there are individuals who have an interest in selling stock or real estate. These advisors provide misleading information to buyers who then act on these incorrect messages. Real estate agents do have the motive to encourage buyers to bid and are typically given plenty of time in which to make that case.

Naturally, these models assume a degree of irrationality—individuals still listen to advisors who are patently self-interested. Yet, this attention to the opinions of others may itself be an entirely sensible rule of thumb. Most of the time, advice is given disinterestedly (i.e., one's spouse or mother advises that you wear a coat because it is raining), and it is best not to waste too much effort trying to understand the motives behind the advice. Perhaps, we follow the advice that we are given because that is a relatively sensible strategy most of the time.

One attractive aspect of the "entrepreneurs of error" approach is that it appears to offer more testable implications than the simple herding view. Herding models, like agglomeration models in urban economics, yield the prediction that individuals will act similarly. Yet, it remains unclear whether the correlation across individuals reflects herding (or agglomeration) or just some omitted factor that acts on everyone simultaneously. By contrast, the "entrepreneurs of error" approach offers the strong prediction that herds will move in the direction implied by the error suppliers with strong incentives and persuasive talents.

We are not ruling out any number of possible models with cognitive limitations, but this research agenda is sufficiently early that we suspect that concentrating on a small

number of alternatives to complete rationality is sensible. We suspect that there is an agenda around extrapolative beliefs involving theoretical research, normal empirics, and lab work that will be highly productive. A better understanding of why the implications of elastic supply seem to be so often ignored also seems relevant. Finally, for exploring some elements of housing institutions or policies, it will remain sensible to take the easy if hard to defend approach of just assuming exogenous beliefs.

11.5.5 Directions for future research

We are at the dawn of research on near-rational models of housing markets and housing bubbles. On the theoretical front, we are particularly enthusiastic about models with simple deviations from rationality that can produce the stylized facts discussed in Section 11.3. Ideally, we would be able to focus on a single form of near-rationality, rather than having an explanation for each anomaly. We think that microfounded extrapolation models and social learning models are particularly likely to be worth further investigation.

There is also a need for a broader set of empirical tools in this area. Many behavioral quirks have been investigated in the lab, but lab conditions are far from the conditions experienced when families are shopping with real estate agents. Field experiments would seem like a priority here. More generally, good behavioral models will yield new testable implications, and those implications will enable us to judge their further value.

There is also a specific need for normative analysis with near-rational homebuyers. What should the optimal policies towards the home mortgage interest deduction be when homebuyers are overoptimistic or trend chasing? How do behavioral idiosyncrasies relate to land use controls? Any normative analysis should also presumably pay some attention to the possible near-rationality on the part of regulators, legislators, and voters.

11.6. PUBLIC POLICY AND BUBBLES

Real estate bubbles relate to public policy both positively and normatively. On the positive side, many observers have argued that government policies, including the low interest rates, the Community Reinvestment Act, and support for Fannie Mae and Freddie Mac, helped to cause the bubble and its burst (e.g., Wallison, 2009). We have already argued that it is hard to see any simple connection between easy credit and the housing bubble, which leads us to be cautious about accepting the view that such policies obviously caused the boom. It remains, of course, possible that these policies exacerbated the bubble and its financial implications, but it seems hard to blame the government for the fluctuation. Moreover, the history of real estate bubbles suggests that they have often occurred when government intervention is minimal (Glaeser, 2013).

We turn to the normative, public policy implications of housing bubbles for different parts of the public sector. Most obviously, macroeconomic institutions, such as the Federal Reserve Board, debate whether to engage in policies explicitly aimed at reducing

the volatility of asset bubbles, including real estate bubbles. Bank and credit regulators have oversight over institutions that are deeply impacted by real estate fluctuations. How does the existence of real estate bubbles impact optimal banking regulations? The federal government engages in a series of housing market policies, including the home mortgage interest deduction. Should these policies be changed in light of recent real estate volatility? Finally, local land use regulations are largely responsible for shaping housing supply. These regulations also interact with housing bubbles (Glaeser et al., 2008).

We have no intention of resolving these policies issues now, but we note them primarily as enduringly important topics. The Federal Reserve Board has historically abstained from taking steps to deflate asset bubbles. For example, in 2005, Janet Yellen articulated the current orthodoxy that monetary policy should not be used to deflate a housing bubble. She asked "if the bubble were to deflate on its own, would the effect on the economy be exceedingly large?" and refuted that claim. More importantly, she argued that monetary policy is not "the best tool to use to deflate a house-price bubble."

History has not been kind to her first argument against intervention. The real estate bust did have widespread adverse consequences and the threat of future housing busts seems quite real. To be fair, many housing economists (including at least one of us) were at least as mistaken as she was. Still, after learning the Great Recession, future policy makers should never be so confident that a housing downturn won't have serious consequences.

But what awareness of the risks means for macroeconomic policy making is far less clear. Yellen's point that monetary policy is not a good way to "deflate a house-price bubble" is just as tenable today as it was in 2005. Moreover, since housing price booms can reflect real forces, as well as bubbles, it may be foolish to constantly attempt to run counter to rising prices. The policy conclusion is uncertain, but that provides a far clear implication that more research is needed on macroeconomic stabilization policy when real estate volatility is large.

The volatility of real estate prices also impacts financial market regulation. The Lehman Brothers' bankruptcy was closely connected with its exposure to real estate-related subprime mortgage risk. Indeed, the securitization of mortgages has been blamed not only for helping to create the bubble but also for ensuring that the pain of the downturn is more widely experienced. Yet, the spreading of that risk may have reduced the adverse consequences of the bubble for the banking system itself, since fewer mortgages were being held directly on the books of lending institutions.

The obvious implication of centuries of real estate booms and busts is that real estate is not a riskless asset. Regular mean reversion means that high prices today may well mean low prices tomorrow. Presumably, these facts should inform banking regulation if the goal of such regulation is to reduce the risk of financial distress within the sector.

One suggested reform is that regulators should anticipate mean reversion when assessing asset values for capital requirements. If prices have risen by 75% over the past 5 years, then historical experience suggests that a 25% drop over the next 5 years is not unreasonable. One proposal is to value real estate–related capital based on its future expected value.

Yet, there are many reasons to be cautious about changes of this kind. Real estate is not the only asset that displays mean reversion (Cutler et al., 1991), but if real estate is the only asset that is subject to such treatment, then this may distort the movement of capital. Whatever formula is used to assess long-run value will surely be subject to gaming by lending institutions and political influence by policy makers seeking their own pet objectives. Again, the only conclusion that can be definitively drawn now is the need for further investigation.

The federal government has explicit policies that promote homeownership typically by subsidizing lending. The home mortgage interest deduction implicitly subsidizes home borrowing. While borrowing for business investments may also be deductible, typically, the returns to those investments are taxed. By contrast, the government does not tax the implicit rental income earned by a homeowner. The government-sponsored enterprises, Freddie Mac and Fannie Mae, as well as the Federal Housing Administration, have also all encouraged home borrowing by providing a guarantee against default.

The presence of real estate bubbles matters deeply for the wisdom of encouraging leveraged bets on real estate through public policy. If real estate was a safe, boring asset that rarely experienced major fluctuations, then encouraging homeowning could be seen as a safe means of encouraging asset accumulation. However, high levels of volatility mean that government policies that support leveraged borrowing can have the unfortunate impact of creating a class of homeowners who are massively indebted because they borrowed to buy housing that has lost its value.

To a certain extent, this downside risk is offset by the fact that the cost of living for these homeowners has dropped. Owning itself is something of a hedge since we are all born short housing (Sinai and Souleles, 2008). Yet, there is also a covariance between local housing prices and local labor markets, which helps explain why the downturn was associated with so many foreclosures. Those foreclosures provide a tangible example of the risks associated with encouraging leveraged REITs particularly for lower income Americans.

The supporters of pro-home borrowing policies will often point out the large share of housing in the portfolios of many Americans, as if this proves that subsidizing homeownership is the natural path towards encouraging asset accumulation. Yet, since many of these policies make it easier to borrow with low down payments, they also reduce the incentive to save before buying. There is a severe need for a more serious literature about the portfolio implications for ordinary Americans of encouraging home borrowing, especially in light of significant house value volatility.

The final relevant policy area relating to real estate bubbles concerns the land use policies of the local government. Housing supply is determined, at least in part, by regulations at the local level. Housing supply then in turn influences the nature and duration of real estate bubbles. The first-order correlation is that these events do appear to be more extreme in more restricted areas, both in places that currently cannot build (Glaeser et al., 2008) and in places where investors anticipate future regulatory constraints that make supply difficult (Nathanson and Zwick, 2013).

Does it therefore follow that in a world with real estate bubbles, it is even more valuable to reduce the barriers to new building? Not necessarily. Even if we were confident that fewer restrictions on buildings might make bubbles less common or less extreme, we could not conclude that reducing land use restrictions would reduce the social costs of bubbles. For one of those costs is overbuilding, and overbuilding will be more severe in places where land use is more restricted. It seems doubtful, for example, that the price boom between 2001 and 2006 caused any serious overbuilding in San Francisco or the suburbs of Boston, because so little new housing was built and prices remained significantly above construction costs even after the bust. Their restrictions may have caused price swings to be more severe, but they also limited the hangover from excess building supply. The social cost of overbuilding will be most severe in areas in which supply is elastic and bubbles still occur.

Overall, this policy section has provided no clear policy directives and that is precisely the point. The policy implications of real estate bubbles are far from clear. Economists have not spent all that much time researching this issue, partially because of our unwillingness to accept the existence of bubbles. Yet, the hair-raising events of 2000–2012 make it plain that real estate can experience enormous convulsions, whether we choose to use the word "bubble" or not. Surely, economists must press on to deliver a better apparatus for understanding the consequences of different housing and banking policies in a world where real estate can be very volatile.

The need for policy-related research is enormous. We certainly believe that the positive questions discussed above need to be answered before we can be confident about the bases of public policy, but policy making must often proceed in environments of ignorance. One of the biggest questions is whether regulatory requirements, such as higher reserve ratios, can effectively protect the financial system against future housing busts. The question remains unresolved. Some experts have even argued that higher interest rates are more likely to be effective than regulation because they can act system-wide, impacting the shadow banking sector, for example, in ways that regulation cannot.

If societies contemplate changing the incentives that subsidize home lending, other questions become particularly important. Does the current regime of subsidizing homebuying actually lead to added asset accumulation, or does it reduce the incentive to save for down payments? What does subsidized home borrowing do to the risk profile of normal households?

11.7. CONCLUSION

This chapter has argued that real estate experiences impressive booms and busts, which can reasonably be referred to as bubbles. Generally, prices move too much to be fully explained by changes in either rents or observable fundamentals. Housing prices display substantial momentum at high frequencies, and they mean revert at lower frequencies. These general features were greatly exacerbated during the great boom and bust of the 2000–2012 period. Moreover, real estate convulsions have appeared regularly throughout the United States and world history often with dire consequences.

The economics of real estate bubbles is still in its infancy, for until 2005, the dominant economic view was that such bubbles do not exist. This orthodoxy paralleled the general assumption in financial economics, at least until the dot-com bust of 2000. It seems silly now to believe that housing price changes are orderly and driven entirely by obvious changes in fundamentals operating through a standard model.

Moving ahead, there are two broad classes of models that have and will continue to shed light on these great housing convulsions. The first class essentially attempts to explain these housing market features with essentially rational actors. We have discussed two variants of these models. First, several papers examine housing dynamics through the lens of a search model. These models can generate substantially more momentum than standard models, because it takes time for shocks to work their way through the system. To date, these models generally do not deliver large amounts of excess volatility, just momentum and mean reversion, but those are themselves significant contributions, and it remains possible that future models of learning and search will also generate significant excess volatility, although there are reasons to doubt that this will occur.

A second form of rational model stresses that if agency problems lead to interest rates that charge too little for default risk, then rational bubbles can occur without violating any transversality conditions. These models still tend to predict that prices will become enormously high with positive probability. This implication is difficult to square with elastic housing supply, which suggests that these events are far more plausible in highly constrained areas. These rational bubble models do not imply that cheap credit will always cause a real estate bubble, but they do suggest that cheap credit is a necessary condition.

The second class of models drops the assumption of perfect rationality. We have discussed several different types of these models, including models in which beliefs were just assumed to be fixed and heterogeneous. While that assumption is useful for highlighting cross-sectional aspects of the housing markets, we suspect that productive veins of behavioral real estate research going forward will focus on extrapolative beliefs and simple forms of limited cognition. We sketched a path towards grounding extrapolation as the result of cognitive limitations of the form discussed by Eyster and Rabin (2005). It also seems possible that cognitive limitations may lie behind the buyers' apparent tendency to repeatedly ignore the power of housing supply to determine prices.

Understanding the causes of real estate bubbles seems particularly critical, because these events clearly have large social consequences. We cannot plausibly hope that these asset price fluctuations will vanish, but it is at least possible that we can reduce their costs through better public policy making. Unfortunately, we are still far from having enough knowledge to confidently recommend any particular policy actions.

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