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Endogenous Housing Market Cycles

Abstract:
Housing markets tend to display both positive serial correlation as well as a considerable volatility over time. We present a stochastic model illustrating the connection between adaptive expectations and market fluctuations. All macro economic and demographic variables stay fixed over time and price movements are driven by expectations only. In the case where agents face unconstrained mortgage financing, the housing market oscillations are regular and depend on mortgage to income ratios. When credit institutions are introduced, which view houses as mortgage collaterals, the dynamics get complex. Periods of mild oscillations are mixed with violent collapses in an unpredictable manner.

Keywords: Heterogeneous agents, adaptive expectation, credit score models, house price cycles.

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1. Introduction

Understanding the housing market entails many difficulties. As an extremely heterogeneous asset it is usually fragmented to a number of loosely separated submarkets (Bourassa, Hoesli, Peng, 2003)). Traders in the housing market are a motley mix of professional real estate investors and laymen, where the latter usually intend to live in the acquired dwelling. In many countries owner occupied housing is common, and the lion's share of all transactions occurs between non-professional traders[1]. Buying and selling houses often involves considerable transaction costs. Such costs imply transaction barriers, which potentially make the investment horizon longer than for other assets.

House prices tend to be volatile. Since housing supply is given in the short run, considerable appreciation is expected in times of unanticipated shifts in demand driven by macroeconomic shocks. Furthermore, since individual housing demand varies over the life cycle, demographic trends affect both the housing market as a whole, as well as it has an imbalanced impact on submarkets (Mankiw and Weil 1989, Hamilton 1991, Engelhardt and Poterba 1991). Location is, however, a key explanatory variable for house prices. The aggregate housing market in a country, or a municipality, will be dependent on macro economic factors, but these may be offset, or masked, by factors exclusive, or at least partially exclusive, to a given house, driven by locality at a finer scale. In essence, every dwelling is unique, and offer a unique set of housing services to its owner, which make house prices both difficult to predict and linked to psychological factors, strongly influenced by expectations (Schiller 1990).

Market cycles can be modeled and explained in many different ways. Ezekiel (1938) presented the cobweb model. His cobweb theorem states that under certain circumstances time-persistent fluctuations may arise. A typical situation is one where large supply produces a low market price, which again reduces supply, something which again leads to higher prices. In the cobweb model the actual behavior of agents is not explicitly given. More recent contributions have studied the interplay between expectations and price formation showing how price fluctuations can occur both under the rational expectation hypothesis (hereafter REH), and under weaker rationality assumptions. Under REH cyclic behavior can occur under laissez-faire, if agents predict that they will do so (for a survey see Boldrin and Woodford 1989). From a game theoretic point of view, price formation may be conditional upon the common knowledge information set. Negroni (2004) takes this point of

[1] Laymen, however, oftentimes have assistance from real estate agents.

departure, and studies how expectations may converge to produce either equilibria or cycles. Evolving expectations may also arise by assuming bounded rationality, and allow agents to update expectations over time. One possibility is to assume that agents derive their expectations from time series observations, as in Sargent (1993,1999). In particular, several authors have developed heterogeneous agent models where boundedly rational agents use simple strategies (Arthur et al. 1997, Brock and Hommes 1997, 1998, Kirman 1993, DeLong 1990, Sonneman et al. 2004), giving rise to both periodic and highly irregular price movements.

After the seminal paper by Muth (1960), adaptive expectations have been widely used in macroeconomic inflation models (Rudebusch and Svensson 1999), and several extensions to the optimality of adaptive expectations under various assumptions of the underlying data generation process have been proven (Satchell and Timmermann, 1995). Adaptive expectations are susceptible to the Lucas Critique, and may be far from optimal when negative serial correlation is likely. However, adaptive expectations and positive serial correlation can be linked as adaptive expectation may spur positive serial correlation, and a tendency of persistent price patterns may rarely punish adaptive rules of action. In the case of housing markets, empirical work (Case and Schiller 1989) indicates price movement persistence, possibly in violation of a market efficiency hypothesis. Cho (2004) surveys the literature on housing market efficiency, and concludes that markets tend not to be informationally efficient. Furthermore, both house prices and excess returns exhibit short run serial correlation. However, if central banks are worried about asset inflation and target house prices negative serial correlation can be the result. Furthermore, lags in housing supply can also challenge the near-rationality assumption of adaptive expectations, if increased supply is not met by increased demand.

Our point of departure is a housing market model with heterogeneous agents, where houses are traded through one-bid sealed auctions and transactions occur when the highest bid exceeds the seller's reservation price. Agents are assumed to be adaptive, and base their forecasts on the recent price history, represented by a house price index. Our approach connects to recent contributions by Negroni (2004) and Sonnemann et al. (2004). We apply a slightly different definition of the adaptive expectation rule, and learning plays a lesser role in our model. We assume that agents enter the market only once, form their conjectures, their reservation price, place their bids and transact. Preferences are assumed to be heterogeneous, both with respect to a given house that is for sale, and with regards to an agent's weighing of investment versus consumption. All demographic and macroeconomic variables are fixed, making all price variations dependent on expectations alone. The aim of this model, which is presented in section 2 and 3, is twofold. First of all to construct a minimal model that displays purely expectation-driven market volatility. Secondly, to use this model as a starting point for several extensions that we believe cuts into the essence of price formation in housing markets.

Mortgage financing is common in most housing markets. We consider the role of mortgage financing along two lines. First by considering market volatility as mortgage-to-equity ratio varies. We show using simulations how allowing for an equity distribution among prospective buyers tends to smooth cycles as buyers now meet their bid thresholds at different price levels, even in the case where there are no credit constraints. Market oscillations in these scenarios tend to be periodic. The second approach is by modeling credit institutions. In contrast to buyers and sellers bid and acceptance rules, which are concealed to us, the structure of credit score models is known. Credit score models involve a weighing of agent specific and investment specific factors, where the latter is related to general market conjectures. In particular, mortgage size is generally conditional on a house price forecast in addition to agents' equity (if any) and income. The multiple of the latter often serves as a mortgage ceiling, under which the buyer is expected to meet her mortgage obligations. In section 4, we study the price dynamics following the procyclic credit rationing implied by credit score models. Increased volatility, as well as unpredictable market collapses, is prevalent. The equity distribution still lowers volatility, and makes market collapses less frequent, but the basic dynamics remain.

Section 5 studies the interplay between two market segments. High mortgage-to-equity ratios can be expected as more dominant in the submarket for starter homes. In other market segments, for instance in the market for family homes agents usually have net equity, and may rely less on mortgage financing. However, an agent's net equity may depend uponb selling a starter home, and if this is true for most agents, the two markets are interlinked. We study submarket linkage by letting sellers of starter homes act as buyers of family homes. The simulations illustrate that market volatility, and the effect of credit rationing, spread from the market for starter homes to the market for family homes as equity in the latter is conditional on mortgage supply in the former.

2. A simple housing market model: Relating the fair price to the price index

In this section we present a simple housing market model. The model is designed to capture a few main characteristics of a housing market where agents rely on adaptive expectations and discard all other factors. One property that can be argued exclusive to housing markets is the multiple roles of houses. They satisfy housing consumption need, are investment objects and serve as collateral for mortgages. The model seeks to illuminate the market dynamics when agents mix consumption and investment motives in housing demand, and potentially suffer credit constraints. At a more general level the model simulations display the complex dynamics that arise when the three agent types, interact in a market where the asset traded has multiple properties that are in general priced differently among agents. The model is constructed to serve this purpose only and great emphasis has been made on making only assumptions that are strictly necessary to capture expectation driven price dynamics. In particular, all macro economic and demographic parameters that need to be specified in the model are assumed to be constant.

The model consists of buyers, sellers and houses. In each period a number of houses N_{new} are for sale the first time. In addition, some houses from previous periods $N_{lay\ overs}$ may still be in the market waiting to be sold. Hence, the total number of houses that are for sale in a given period is $N_{houses} = N_{new} + N_{lay\ overs}$.

All houses are assumed to be equal, with respect to size and standard. However, we allow for heterogeneity between actual bids for a given house. We may interpret the differing valuation across households as a sign of house specific preferences. For instance, geographic location may vary, but no location is generally accepted as better than another. The house price index is calculated by a simple mean of transaction prices. This index is free of composition effects, since houses are assumed to be hedonically identical. However, the index can have a selection bias in the sense of Gatzlaff and Heurin (1997), since only traded houses are included in the index[2]. This may give the index an upward bias.

To each of these houses a seller is given. She accepts a bid if it is above her reservation price. The reservation price is a function of the price index in the previous period. In mathematical terms, we apply the following acceptance rule:

(S1) Accept if $P > a^n\ I_{t-1}$, where $0 < a < 1$ and n is the number of periods the house has been on the market.

In order words, a seller relates the acceptable price to the most recent observed price level, defined by the price index in the previous period. In the simulation the parameter a is chosen close to 1, which is to say that the seller expects a bid close to the price index, but views this as a crude estimate and is

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[2] This bias is expected to be upward, since a house that remains unsold implies that its highest bid, which may be viewed as the market price, failed to exceed the seller's reservation price, leaving the house from being included in the market price. Thus, in our simulation the index can in this sense be biased during depreciations.

willing to accept a somewhat lower price. If the house is not sold the first period it is on the market, the seller updates her reservation price, accepting if $P > a^n \, I_{t-1}$: that is, always relating the value of her house to the commonly known price index, based on the transactions in the previous period, but in addition updating her reservation price as a reaction to the absence of acceptable bids[3]. This may be taken as a sign of a growing preference for a sale over time. An alternative interpretation may be that over time she may suspect that her house has some undesirable characteristics, making comparison to the general index less relevant. In real housing markets this type of learning (the hard way) may be common. In our model, such an interpretation rest on an assumption of that homogeneity with respect to housing hedonics is not common knowledge.

The actual form of this update is not crucial. What is important though is that the absence of bids makes the seller reduce his reservation price compared to the price index. The rationale for such a reduction is twofold. The seller may acknowledge that for some reason unobservable to him, potential buyers find his house less attractive. Or that he over time has increased his preferences for selling now instead of later, thus lowering his reservation price in order to increase the probability of a transaction.

Potential buyers come from a homogenous group; they all have an equal and fixed amount of income *Y*, normalized to 1 each period. They are subject to a given mortgage interest rate *r*, fixed over all periods, and a payment on the principal payment plan, given as a payment rate r_p[4]. Furthermore, households are assumed to have equity *E,* and rely on mortgage financing when the price of a purchased house exceeds *E*.

In this stylized model, buyers are only followed one period. Their decisions are based on recent housing price history and rule of thumb conjectures regarding budget share allocations between housing outlays - mortgage interest and payments on the principal - and consumption of other goods and other investments. Their decision process is modeled as follows: Every prospective buyer renders a certain budget share, s_0, of this period income, as a threshold for housing outlays. If prices are expected to rise households may accept a somewhat higher budget share, *s*. We may think of s_0 as the highest acceptable budget share, when only housing consumption motives are present. Furthermore, the difference $s - s_0$ is a measure of the eagerness to invest, and the willingness to accept less consumption today compensated by higher future consumption.

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[3] Such static price expectations $P_t^e = P_{t-1}^e$ are called naïve expectations (Hommes (1998) p. 338).

[4] If the potential buyer considers 20 payments on the principal over 20 time periods $r_p = 1/20 = 0.05$.

The affordability criterion can be expressed as

(B2) $$AC = sY/(r + r_p) + E$$

where Y is income, r the mortgage interest rate, r_p is rate of payment on the principal, E equity, and (s) the budget share. Furthermore, $s = s_0 + u_{ac}$, where u_{ac} is a stochastic term drawn. In the simulations below, s_0 is set to be ¼ and u_{ac} is drawn from a uniform distribution on [0,0.05], thus allowing a budget share for housing outlays up to 0.3 of the income.

The affordability criterion can be viewed as a personal threshold of housing outlays versus consumption of other goods. When prices are high this condition may be binding. In general however, a notion of fair price must be in place and govern a potential buyer's bids. A price forecast based on prehistory and adaptive expectations is $(I_{t-1} + \Delta I_{t-1})$ [5]. As in the case of affordability, we allow heterogeneity across agents by introducing a stochastic term, providing a distribution of subjective fair prices around the index forecast value. Hence, the fair price can be expressed as

(B3) $FPC = u_{fpc}(I_{t-1} + \Delta I_{t-1})$ where u_{fpc} is a stochastic term.

The auction process is modeled the following way. For each house, potential buyers enter the auction with probability $1/N_{houses}$. That is, every prospective house seeker is expected to enter one auction each period. If a potential buyer enters the one bid sealed auction, he places a bid equal to the minimum of AC and FPC. In other words, he chooses his fair price unless it is in conflict with his affordability constraint. In the latter case, the affordability constraint is binding.

The asymmetry of sellers and buyers with respect to the specification to adaptive expectations is chosen to reflect the asymmetry in the transaction process. Sellers want to sell, but not at any price. This reservation price is a function of the most recent observed prices. If bids are much higher, a low reservation price does not matter. Prospective buyers, on the other hand, enter the auction to win, and place bids conditional on their price expectations.

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[5] This definition differs from Hommes' (1998) definition p. 341, $(P_t^e = P_{t-1}^e) + w(P_{t-1} - P_{t-1}^e)$, but the buyers' adaptive expectations are naïve in the sense that they believe that the observed price *change* will prevail.

3. Market oscillation driven by investment motives and adaptive expectations

In this section we will consider two simulation scenarios based on the simple framework presented in the previous section. Consider first the case where sellers reservation price criterion (B1) is applied when $a = 0.95$, that is they relate the value of their house to the price index but allow up to a 5 percent deviation. Furthermore, if their house is unsold after a period, an additional reduction of roughly 5 percent is acceptable each period. Apart from the heterogeneity in case of unsold houses, sellers are assumed to be identical. In the absence of investment motives, buyers find a budget share of ¼ for owner occupied housing, which is mortgage rates and payments on the principal, as an upper limit for housing outlays. In the case of house appreciation $\Delta I_{t-1} > 0$, heterogeneity with respect to the budget threshold is introduced. Potential buyers are drawn from a uniform distribution on [0.25, 0.30]. Furthermore, their fair price criterion is drawn from a uniform distribution of 10 percent around the price forecast $I_{t-1} + \Delta I_{t-1}$. All buyers consider a combined burden rate (mortgage interest + payments on the principal) equal to 0.08[6]. They have an income *Y* normalized to 1, and equity *E* equal to 0. As simulations starts agents observe $I_0 = 3$, and $\Delta I_0 = 0$, 1000 houses is put on the market for the first time, and 3000 potential buyers are considering placing bids. In other words, the ratio of buyers to houses is 3, implying on average three bidders per house, all entering a one-bid sealed auction. In each subsequent period 1000 houses (N_{new}) and 1000 buyers ($N_{new\ buyers}$) enter the housing market. The first simulation scenario is summarized in table 3.1.

[6] This may correspond to a mortgage interest rate of 3 percent and serial loan over 20 time periods. Note however that the dynamics is independent of the respective sizes of r and r_p and depend only on the sum r+r_p. Furthermore the sum only affects the ceiling of bids.

Table 3.1: The case of adaptive expectations and no credit rationing

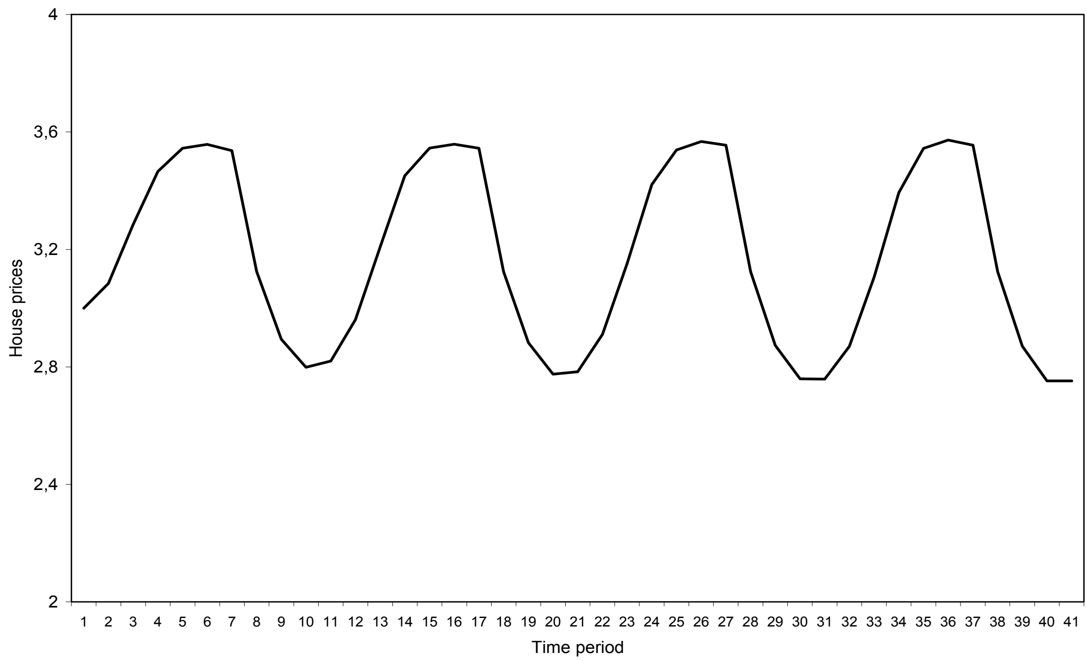
Agents/macro	Exogenous parameters	Exogenous parameters	Stochastic distribution*	Initial values endogenous variables
Sellers	$P > a^n I_{t-1}$ $N_{new} = 1000$	$a = 0.95$	*none*	$I_0 = 3, n = 1$, $N_{lay\ overs} = 0$
Buyers	$AC = sY/(r + r_p) + E$ $s = s_0 + (1 + sign(\Delta I_{t-1}))u_{ac}$ $FPC = u_{fpc}(I_{t-1} + \Delta I_{t-1})$ $N_{new\ buyers} = 1000$	$r + r_p = 0.08$ $Y = 1$, $s = 1/4$, $E = 0$	$u_{ac} \sim u[0, 0.025]$, $u_{fpc} \sim u[0.9, 1.1]$	$I_0 = 3$, $\Delta I_0 = 0$, $N_{buyers} = 3000$

* Note that lack of heterogeneity not is a model limitation. As transactions are based on the difference between bids and ask, a stochastic distribution on both bids and reservation prices is *equivalent* to a distribution on either bids or asks.

Figure 3.1 shows the price dynamics corresponding to table 3.1. Appreciation spur investment motives and drives prices above the maximal price level defined by consumption motives alone (3.125[7]). As prices climb above 3.5 and towards the absolute threshold 3.75, corresponding to a budget share of 0.3, prices flatten out. The bidding reflects that high appreciation no longer is anticipated, and the price index measuring realized transactions shows a small depreciation. As a price fall deter investments, prices fall sharply until consumption motives alone dominate demand. As steep price falls no longer are anticipated, bids are again affected, and induce a small appreciation. As appreciation again is observed, investment motives boost prices and the cycle starts all over again.

[7] House price = ¼ (1/0.08)= 3.125

Figure 3.1: House price fluctations in the case of adaptive expectatons and no credit rationing



A few remarks about the model and the dynamics are in order. The backbone of the modeling is an "in vitro" stochastic experiment, where no macroeconomic or demographic changes are present. In each period a given and fixed number of new house seekers enter the market. This number is matched by the number of new houses that are put on the market for sale. The agents face no uncertainty about wages, interest rates or payment plans. All prospective house buyers have some intertemporal utility function which is maximized. This maximization results in a bid, which we model. In other words, we implicitly assume that other capital markets and housing rental markets are synchronized and thus leaving the number of agents, their bids and asks. Compared to the model of Stein (1995) where excess demand is the key notion for price variation and changes in transaction volumes, differences in transaction volume is in our model driven by the seller's hesitation to reduce prices. This gives an initial - and in the case of general depreciation - a high reservation price compared to most of the actual bids. If the house remains unsold, the seller updates the price index, which is the basis for his reservation price, based on the actual transactions that took place last period, but lowers his price expectations as a response to absence of acceptable bids on her own home.

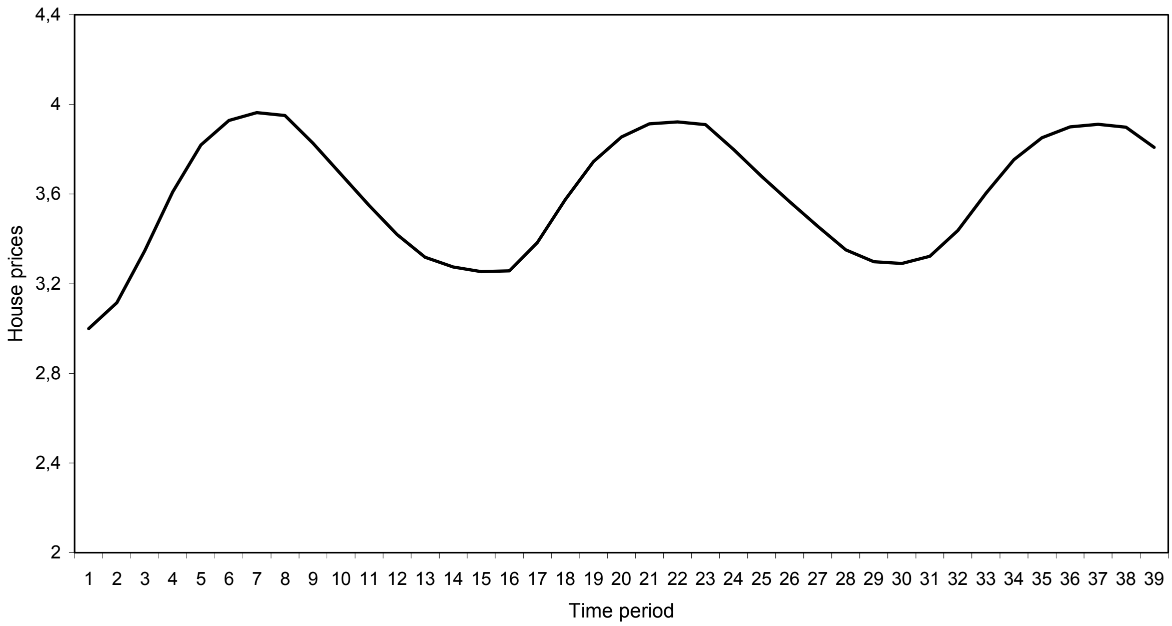
It must be noted that the amplitudes and "wavelengths" depend critically of parameters that are more or less arbitrary within plausible limits. However, both the periodic behavior and the sharper down-falls in comparison to up-swings are robust features. The steep declines are partially driven by lack equity heterogeneity among buyers. An equity distribution tends to make affordability constraint less severe for a portion of prospective buyers, making the fair price criterion more important, in which an agent may on occasion choose to deviate up to 10 percent from the forecasted price index. Concretely, a prospective buyer with equity E, relies on the same fair price criterion (FPC), but relaxes the affordability constraint (AC), since she may use the equity in full. In order words, her bid becomes $\min(AC + E, FPC)$. Figure 3.2 displays the dynamics in the case half of the potential buyers are assumed to have equity, and the equity is drawn from a uniform distribution on [0,1]. In other words, half the population has expected equity of half the time period of income. Table 3.2 sums up the simulation scenario where an equity distribution among buyers is explicitly assumed.

Table 3.2: The case of adaptive expectations, no credit rationing and an equity distribution

Agents/macro	Exogenous parameters	Exogenous parameters	Stochastic distribution	Initial values endogenous variables
Sellers	$P > a^n I_{t-1}$ $N_{new} = 1000$	$a = 0.95$	*none*	$I_0 = 3, n = 1$, $N_{lay\ overs} = 0$
Buyers	$AC = sY/(r + r_p) + E$ $s = s_0 + (1 + sign(\Delta I_{t-1}))u_{ac}$ $FPC = u_{fpc}(I_{t-1} + \Delta I_{t-1})$ $N_{new\ buyers} = 1000$	$r + r_p = 0.08$, $Y = 1$, $s = 1/4$	$u_{ac} \sim u[0, 0.025]$, $u_{fpc} \sim u[0.9, 1.1]$ $E \sim u[0,1]$ *with probability* $1/2$, $E = 0$ *otherwise*	$I_0 = 3$, $\Delta I_0 = 0$, $N_{buyers} = 3000$

The intuition behind the smoothing nature of equity heterogeneity is the following; in contrast to the no equity case, agents approach their personal threshold for housing consumption/investment at different stages in the house price cycle. In other words equity heterogeneity smoothes the price cycle through a less coordinated response to budget constraints and price levels. The link between market volatility and coordination of agent response becomes more apparent, when we model credit institution behavior in the next section.

Figure 3.2: House price fluctuations in the case of adaptive expectations and no credit rationing, but with an explicit equity distribution among households



4. Credit rationing

Housing markets have several properties that separate them from other assets markets. One is the mix of housing and investment motives in demand, as modeled and simulated in the previous two sections. Another is mortgage financing, where the acquired dwelling serve as collateral. Mortgage financing tends to be conditional on past, present and forecasted house prices, as well as the size of down payment and socio-economic characteristics of the mortgage seeker.

The credit institution relates the full size of the mortgage to the forecasted house price level next period $\left(I_{t-1}+2\Delta I_{t-1}\right)$. Following Kiyotaki and Moore (1997) we assume that the present value of collateral $\left(I_{t-1}+2\Delta I_{t-1}\right)/\left(1+r\right)$ gives the market driven lending constraint. In addition, agent specific considerations may affect individual constraints, and we model this by taking a stochastic spread around the Kiyotaki-Moore threshold. Hence, the credit rationing (*MBC*) is given by

(C4) $$MBC = u_{mbc}\left(I_{t-1}+2\Delta I_{t-1}\right)/\left(1+r\right)+E\,.$$

A few comments are in order. The condition in (C4) implies a hypothesis of risk neutrality, as credit institutions only considers the expected price index ignoring uncertainty related to future price level and the realized value if the house is sold. Moreover, the forecast is based purely on adaptive expectations. In the case of credit institutions, the hypothesis of adaptive expectations based on recent price history may be challenged. In fact, credit institutions tend to rely on a rule of thumb when granting mortgages, invoking a ceiling defined by a multiple of the yearly income. Such a condition serves as an extra precaution, in addition to the risk neutral evaluation in (C4). A possible story for this rule of thumb is the following. Credit institutions realize that forecasts can prove wrong. Furthermore, they assume that house owners will hesitate to sell if the transaction price does not meet their mortgage obligations. In other words, credit institutions rely on the house owner’s incentive to avoid personal bankruptcy. A manageable mortgage-to-income ratio increases the probability of weathering the storm in times of depreciation.

The mortgage ceiling may be viewed as a way to reduce the probability of forced sales during depreciation. Most likely, house owners also hesitate to sell when the selling price is lower than the mortgage. In short, the mortgage ceiling routinely used by credit institutions may be viewed as a rule of thumb acknowledging the weakness of the risk neutral mortgage rule (C4). Furthermore, the condition may be interpreted as a risk management condition. Credit institutions realize that forecasts can prove wrong, and hand out credit more conservatively than risk neutrality and forecasts should suggest. We apply a rule for the mortgage-to-income ratio, an obligation constraint (*OC*), as the second condition limiting mortgages.

(C5) $$OC = a_3 Y + E$$

where a_3 is a positive number.

The actual ratio a_3 can in the real world be expected to vary over time, and to be conditional on expectations regarding future interest rates. In our simulation however a_3 remains fixed over time, since mortgage interest does not change over time.

The simulations in the previous paragraph showed oscillation with an almost clockwise regularity. We may picture agents as a herd that picks up momentum as prices rise, and is believed to continue to do so. After prices reach a somewhat blurry threshold, the price curve flattens, and as soon as investment motives are gone, prices start to fall. Prices continue to fall until they are low enough to be attractive for the lion's share of house seekers, even in the absence of investment motives. Then prices flatten out, but pick up momentum again as investment motives comes into play. In the case of credit rationing, the dynamics however gets more complex, as indicated by figure 4.1.

Table 4.1 gives an overview of the model. Two new exogenous parameters are introduced. The first is the mortgage interest rate, $r = 0.03$ which is chosen in compliance with $r + r_p = 0.08$, hence giving a payment on the principal rate equal to 0.05 (as remarked in footnote 3). The second is the threshold for the income to mortgage ratio, which is set to 3.57. The reason for such a number, rather than a seemingly more natural ratio like three or four is the following; buyers are in this simulation scenario subject to four different bid constraints, and for most parameter choices (of r, r_p, s, a_3) one or two of these may be a priori fulfilled. This implies that in order to close the model in a non degenerate way, an implicit relationship between the exogenous parameters must be given. In this particular case, a mortgage to income ratio equal to 3.57 ensures that credit rationing may or may not arise, depending on recent price history.

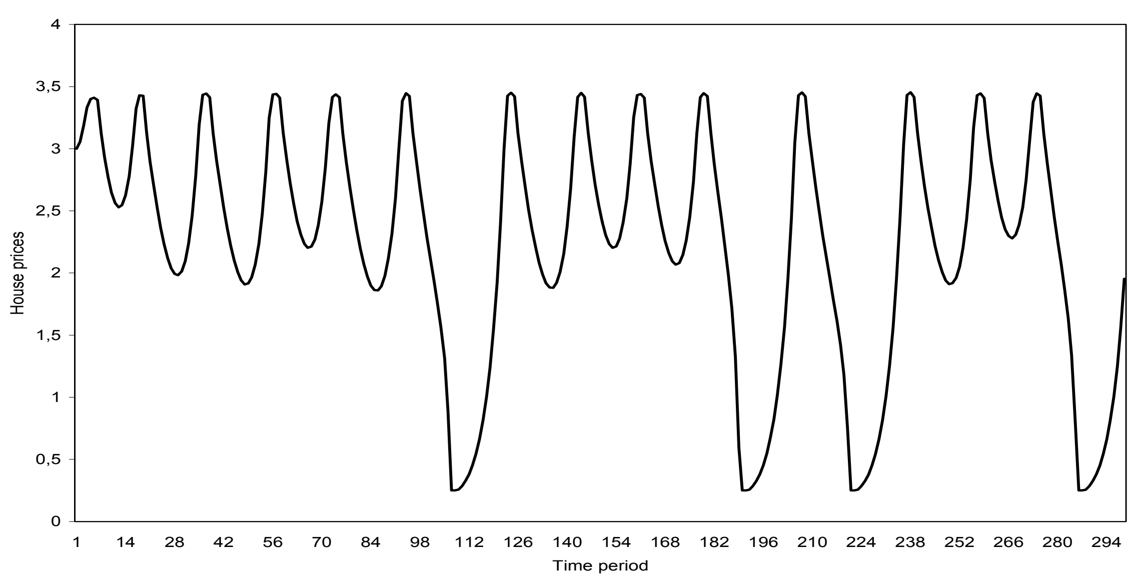
In addition, to allow for procyclic credit rationing, a refinement of the buyer's notion of fair price is done. A bid equal to ¼ is always considered to be fair. In other words, if an agent can acquire a house without mortgage financing, and do not exceed the maximal budget share in the absence of investment motives, she will do so.

Table 4.1: The case of adaptive expectations and credit rationing

Agents	Exogenous parameters	Exogenous parameters	Stochastic distribution	Initial values endogenous variables
Sellers	$P > a^n \ I_{t-1}$ $N_{new} = 1000$	$a = 0.95$	*none*	$I_0 = 3, n = 1$, $N_{lay\ overs} = 0$
Buyers	$AC = sY/(r + r_p) + E$ $s = s_0 + (1 + sign(\Delta I_{t-1}))u_{ac}$ $FPC = \min(1/4, u_{fpc}(I_{t-1} + \Delta I_{t-1}))$ $N_{new\ buyers} = 1000$	$r + r_p = 0.8$, $Y = 1$, $s = 1/4$, $E = 0$	$u_{ac} \sim u[0, 0.025]$ $u_{fpc} \sim u[0.9, 1.1]$	$I_0 = 3$, $\Delta I_0 = 0$, $N_{buyers} = 3000$
Credit institution	$MBC = u_{mbc}(I_{t-1} + 2\Delta I_{t-1})/(1 + r) + E$ $OC = a_3 Y - E$	$r = 0.03$ $a_3 = 3.57$	$u_{mbc} \sim u[0.9, 1.2]$	

Figure 4.1 shows that after a few periods with up-swings and down-falls much in the same way as in the non credit rationing scenario, a total collapse occurs. The depreciation eventually stops, when prices are so low that mortgage financing is not necessary. After a few fairly mild price oscillations the market collapses again. The intuition behind this behavior is the following: In the case of mortgage financing bids are more sensitive to recent price changes since credit institutions only focus on forecasted prices and investment risk, thus limiting agents' subjective housing consumption opportunities, and propensity to invest in housing during depreciations.

Figure 4.1: House prices fluctuations in the case of adaptive expectations and credit rationing



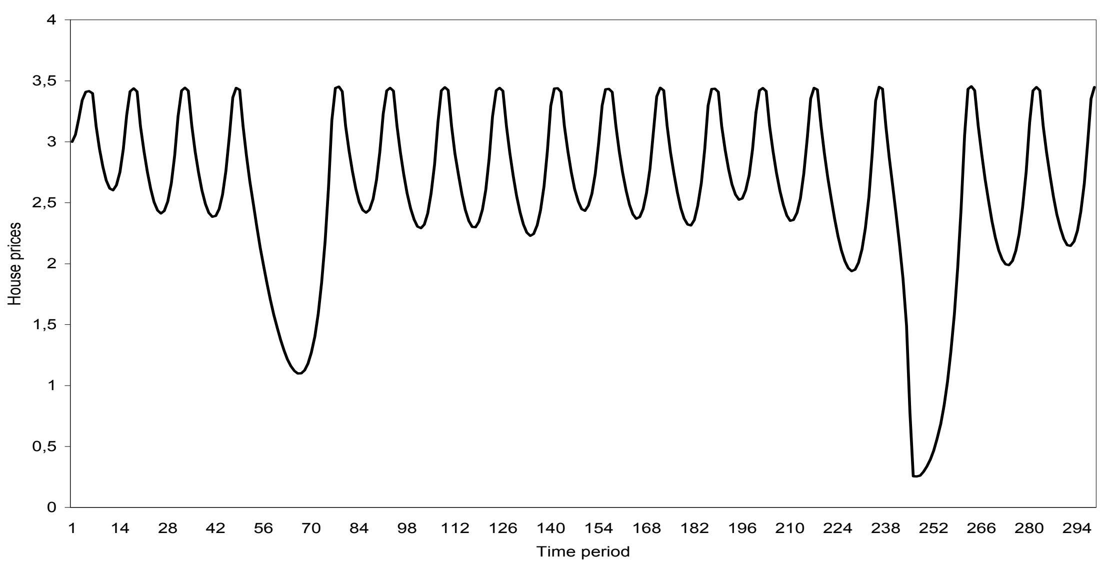
It must be noted the ratio of collapses to milder fluctuations depend heavily of the "tuning" of the parameters. If credit rationing, as implied by the credit score models, dominates the behavior of all agents around the turning point, a market collapse occur with almost certainty. On the other hand, if credit rationing is not binding at all, we are back to the no credit rationing case where market collapses does not occur. Figure 4.1 illustrates a case where agents' reservation price is comparable to the credit score criterions at times of high prices. As in the previous section heterogeneity with respect to the distribution of equity smoothes fluctuations, and, furthermore, reduces the probability of a market collapse. Figure 4.2 illustrates this, showing one collapse during 300 periods when 10 percent of the prospective buyers have equity (uniformly distributed between 0 and one period income 1). The simulation scenario is summed up in table 4.2.

Table 4.2: The case of adaptive expectations, credit rationing and an equity distribution

Agents	Exogenous parameters	Exogenous parameters	Stochastic distribution	Initial values endogenous variables
Sellers	$P > a^n \; I_{t-1}$ $N_{new} = 1000$	$a = 0.95$	*none*	$I_0 = 3, n = 1$, $N_{lay\ overs} = 0$
Buyers	$AC = sY/\left(r + r_p\right) + E$ $s = s_0 + \left(1 + sign\left(\Delta I_{t-1}\right)\right) u_{ac}$ $FPC = \min\left(1/4, u_{fpc}\left(I_{t-1} + \Delta I_{t-1}\right)\right)$ $N_{new\ buyers} = 1000$	$r + r_p = 0.8$, $Y = 1$, $s = 1/4$, $E = 0$	$u_{ac} \sim u[0, 0.025]$ $u_{fpc} \sim u[0.9, 1.1]$ $E \sim u[0,1]$ *with probability* $1/2$, $E = 0$ *otherwise*	$I_0 = 3$, $\Delta I_0 = 0$, $N_{buyers} = 3000$
Credit institution	$MBC = u_{mbc}\left(I_{t-1} + 2\Delta I_{t-1}\right)/\left(1 + r\right) + E$ $OC = a_3 Y - E$	$r = 0.03$ $a_3 = 3.57$	$u_{mbc} \sim u[0.9, 1.2]$	

Table 4.2 displays a combination of regular and complex dynamics which is common in caotic systems. Persistent price cycles show a striking regularity with respect to appreciation turning points. On the other hand, mild oscillations suddenly give way to a total collapse or soft landings at very low prices. Furthermore, mild cycles are aperiodic, and linked to the depreciation turning points that generally vary in a band where prices fluctuate between 2.3 to 2.6, but may however on occasion deviate far from this band.

Figure 4.2: House price fluctuations in the case of adaptive expectations and credit rationing, when 10 percent of all agents are endowed with equity



5. Housing Careers

Most housing markets are segmented. Even though submarkets tend to be vaguely defined, and often have overlaps, they are important for understanding housing markets as a whole. As equity to mortgage ratios may vary across segments, price dynamics may also vary. In particular, the market for starter homes may be more susceptible to credit rationing, whereas households/agents further up the housing ladder may be able to put forth a considerable down payment when buying a home, reducing the effect of credit rationing. On the other hand, submarkets may be linked through up trading. In other words we get a coupling of different market segments, and potential credit rationing affecting one segment may spill over to other market segments.

To illustrate such effects we extend the model by introducing two types of houses, starter homes and family homes. The latter is considered to be a larger and more expensive house type. Both type of houses are treated in the same way as in the previous sections. The only new element is that sellers of starter homes enter the market for family homes as potential buyers. Their net equity is given by the price of their recently sold starter home. Table 5.1 summarizes this simulation.

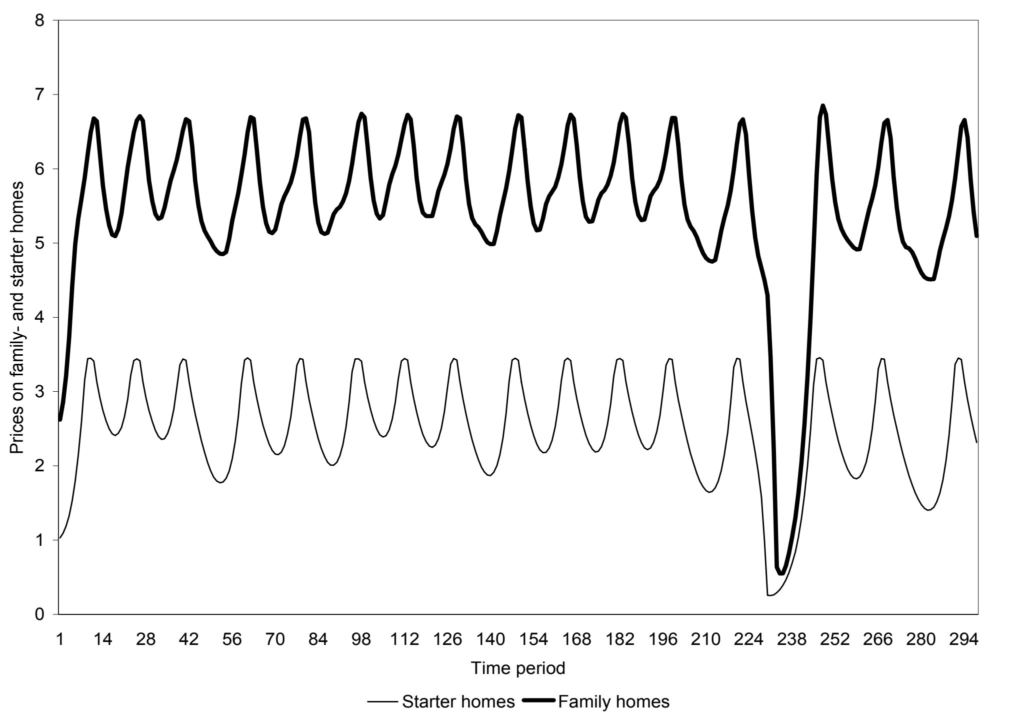
Table 5.1: The case with different market segments and interlinkages between starter- and family homes

Agents	Exogenous parameters	Exogenous parameters	Stochastic distribution	Initial values endogenous variables
Sellers family homes	$P > a^n I_{family\ homes,\ t\text{-}1}$ $N_{new\ family\ homes} = 1000$	$a = 0.95$	*none*	$I_0 = 3, n = 1$, $N_{lay\ overs\ family\ homes} = 0$
Sellers starter homes/buyers family homes	$P > a^n I_{starters\ homes,\ t\text{-}1}$ $N_{new\ starters\ homes} = 1000$	$a = 0.95$	*none*	$I_0 = 3, n = 1$, $N_{lay\ overs\ starters\ homes} = 0$
(up-traders)	$AC = sY/(r + r_p) + E$ $s = s_0 +$ $\left(1 + sign\left(\Delta I_{family\ homes,\ t-1}\right)\right) u_{ac}$ $FPC =$ $\min\left(1/4, u_{fpc}\left(I_{family\ homes,\ t-1} +\right.\right.$ $\left.\left.\Delta I_{family\ homes,\ t-1}\right)\right)$ $N_{new\ buyers} = 1000$	$r + r_p = 0.8$, $Y = 1$, $s = 1/4$	$u_{ac} \sim u[0, 0.025]$ $u_{fpc} \sim u[0.9, 1.1]$ *E endogeneous dist. given by previous sales of starter homes*	$I_0 = 3$, $\Delta I_0 = 0$, $N_{buyers\ family\ homes} =$ 3000 $E = 0(xxx)$
Buyers starter homes	$AC = sY/(r + r_p) + E$ $s = s_0 +$ $\left(1 + sign\left(\Delta I_{starters\ homes,\ t-1}\right)\right) u_{ac}$ $FPC =$ $\min\left(1/4, u_{fpc}\left(I_{starters\ homes,\ t-1} +\right.\right.$ $\left.\left.\Delta I_{starters\ homes,\ t-1}\right)\right)$ $N_{new\ buyers} = 1000$	$r + r_p = 0.8$, $Y = 1$, $s = 1/4$	$u_{ac} \sim u[0, 0.025]$ $u_{fpc} \sim u[0.9, 1.1]$ $E \sim u[0,1]$ *with probability* 1/10, $E = 0$ *otherwise*	$I_0 = 3$, $\Delta I_0 = 0$, $N_{buyers\ starters\ homes} =$ 3000
Credit institution	$MBC_{starters\ homes} =$ $u_{mbc}\left(I_{starters\ homes,\ t\text{-}1}\right.$ $\left.2\Delta I_{starters\ homes,\ t\text{-}1}\right)/(1 + r) + E$ $OC = a_3 Y - E$ $MBC_{family\ homes} =$ $u_{mbc}\left(I_{family\ homes,\ t\text{-}1}\right.$ $\left.2\Delta I_{family\ homes,\ t\text{-}1}\right)/(1 + r) + E$ $OC = a_3 Y - E$	$r = 0.03$ $a_3 = 3.57$	$u_{mbc} \sim u[0.9, 1.2]$	

The simulation is conducted in the following way. In each period all starter homes are sought traded. Those that are give rise to new agents bidding for family homes given their newly acquired equity. As earlier, the probability of entering an auction is $1/N_{family\ homes}$, making the expected number of agents entering an auction equal to $N_{up\ traders}/N_{family\ homes}$.

Figure 5.1 illustrates the price dynamics in both markets. The two markets are linked through the up-traders, and the oscillations are in phase. Furthermore, in the case of a market collapse for starter homes, the equity effect on up-traders results in an even more protouse collapse for family homes than for starter homes, measured in absolute terms. However, the volatility, defined by the ratio of the maximum to the minimum price level, is higher for starter homes (roughly 12 for starter homes while about 10 for family homes). The turning point for the market for starter homes is essentially where the credit rationing seizes to have an effect on prices, whereas the market for family homes starts to recover as equity effects from starter home sales again turn positive.

Figure 5.1: House price fluctuations, starter- and family homes



6. Summary and Discussion

Over the past two decades several advances has been made theoretically to understand persistent price fluctuations in various markets. Cycles may be understood both under a rational expectation hypothesis, and under weaker assumptions concerning agent's ability to gather and process information. In the latter case learning, and potentially improving strategies over time, may influence market dynamics.

Housing markets are extremely complex. Not only may each housing unit be argued as unique, since its location cannot be copied, but prices are influenced by local, macro economic and demographic factors. Moreover, agents are a mix of professional and lay men, where the latter infrequently transact. In this paper we have presented a model, stylized and partial, which we believe capture a few key factors governing the price dynamics in housing markets apart from demographic and macro economic factors. The basic hypothesis is adaptive expectations, where recent appreciations spur investment motives, whereas housing consumption needs remains fixed over time. Furthermore, we introduce credit institutions in addition to buyers and sellers, making dwellings not only a vehicle for housing consumption and investment, but also as mortgage collateral.

We use the model to study price dynamics under the hypothesis of adaptive expectations. In the simplest simulations where unconstrained mortgage financing is assumed, we find periodic price cycles. The cycles are driven by the dual nature of housing. Investment motives spur appreciation beyond consumption motives Absence of appreciation deters investment, and prices fall until housing consumption motives alone justifies transactions, and hence the downward spiral ends.

The dynamic get more complex when houses are explicitly modeled as mortgage collateral. We present a simple credit score model based on guidelines widely used for credit evaluations. This credit score model is procyclic in nature, contributing to increased market volatility. More interesting, is the chaotic dynamics that occur. Cycles may be fairly regular for a number of periods, but suddenly give way for a violent collapse. After the collapse the cycle may recover and resume regular oscillations, or it may collapse again.

Rapid price changes are conditional on coordinated behavior. Collapses occur in the model when credit crunch prevents agents from placing a bid conditional on their housing consumption need. In short, the heterogeneity across agents does not result in a sufficient spread in bids. To highlight the connection between agent heterogeneity and market dynamics, an equity distribution is introduced.

Equity now plays a dual role. First of all it makes agents reach their personal bidding thresholds at different price levels, leading to a less coordinated "herd" of agents. Simulations illustrate this by showing damped oscillations in the case of no mortgage constraints. The second role of equity is to reduce the need for mortgages. Furthermore, credit institutions only consider the collateral of the mortgage part, when lending is driven by credit score models. This structure grants mortgages as long as expected depreciations do not exceed agent's equity. Hence, simulations with equity display chaotic aperiodic fluctuations, but cycles are damped and the occurrence of market collapse less frequent. In general, volatility is closely linked to mortgage-to-equity ratios.

Mortgage-to-equity ratios tends to vary between different segments of the housing market. In the final extension of the model we consider two markets, one for starter homes and one for family homes. The two are linked together through up trading. In the market for family homes the price dynamics is complex. On one hand, equity stemming from selling a starter home makes the direct effect of credit rationing small. On the other hand, mortgage constraints in the market for starter homes affect the equity base in the market of family homes both through the number of transactions and through prices. Both fewer transactions and lower prices reduce equity. The price cycles in the market for family homes show sharp peaks and highly asymmetric recovery faces. Moreover, a collapse in the market for starter homes also induces a collapse in the market for family homes.

Modeling a complex dynamical system with a few basic assumptions comes with a price. This housing market model is no exception. The model offers little insight on cycle duration, amplitudes and likelihoods for violent down falls in real housing markets. However, the model illuminates the dynamics implied by adaptive agents trading an asset that serves three distinct purposes; consumption, investment and mortgage collateral. If true, house prices are always on the drift, even in absence of macro economic changes. Past price history influence agents expectations and the macro effect resemble a tidal wave and give time persistent deviations from the long term trend, either up or down.

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