Heterogenous Agents, Time-varying Macro Fundamental and Asset Market Dynamics

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–Job Market Paper–

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Abstract

This paper proposes a new channel to explain the positive price-volume correlation in the housing market. I study a simple overlapping generations model in the presence of heterogeneous agents. In the model, (i) consumer investors are forward looking and heterogeneous both in their holding periods and in their ownership preference, (ii) the underlying time varying macro fundamental is persistent, (iii) there are no transaction costs/frictions, and (iv) an auction is the micro-mechanism for price formation. In equilibrium, short horizon buyers are more likely to win the asset when prices are high whereas long horizon buyers on average win more when prices are low. This state-dependent ownership structure then naturally leads to a higher expected turnover rate in good times given a (positively) persistent macro dynamics. Empirically I document novel findings that are consistent with my model's asset pricing implications. Owners' *ex ante* holding horizons co-vary negatively with asset prices. Owners' expected durations also have predictive power on future returns, particularly the return component that is forecastable by macro conditions.

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1 Introduction

It has long been a puzzling macro feature that asset prices and turnover rates are positively correlated. Trading is more frequent and volume is higher when prices go up and vice versa. The most recent and striking experience of an asset boom is in the residential housing market in the early 2000's when both turnover rates and prices were high. Within the context of the residential housing market, existing models in the real estate literature often exploit market frictions to explain the phenomenon. For example, Stein (1995) and Ortalo-Magné and Rady (2006) argue the borrowing constraints as a result of credit market frictions restrict borrower's mobility in down markets. Krainer (2001) shows that search costs are less severe in cold markets, making sellers/buyers wait more when prices are low. Alternatively, there is an appealing argument using investors' behavioral limitation as the cause. Scheinkman and Xiong (2003), in a general asset market setting, shows overconfidence can generate heterogeneous beliefs that lead to both high prices and turnover rates. Genesove and Mayer (2001) argue and test (as well as Engelhardt (2003)) the notion that sellers are loss averse and refuse to sell the houses when prices decline. In this paper, I show that the joint dynamics of prices and transaction activities, as observed in the housing market, can be obtained in a rational expectations equilibrium, where (i) consumer investors are forward looking and heterogeneous both in their expected holding horizons and in their preference toward home ownership, (ii) the underlying time varying macro fundamental is persistent, (iii) there are no transaction costs/frictions and (iv) an auction is the micro-mechanism for price formation.

The idea is that if the expected short term market conditions are relatively better in good times, buyers of a shorter holding horizon tend to bid a higher price and thus are more likely to win the asset in the hot market. On the contrary, longer horizon buyers tend to win more in the cold market. Given a (positively) persistent macro dynamics, this ownership structure naturally implies the expected turnover rate is higher in good times and vice versa. While the argument is simple and intuitive, market efficiency suggests that price should not be predictable regardless of holding horizons, since all relevant information is impounded into prices. The channel that leads to predictable expected resale options over the business cycle, that are also consistent with a frictionless rational expectations equilibrium, is through the model's feature that agents are heterogeneous in their home ownership preference and that prices are determined through active bidding with the highest bidder becoming the new owner. The specific mechanism choice, representing a popular microstructure feature of the real world, captures the strategic interaction among buyers for the same housing good. As a result, the transaction price in general will depend on the relative distribution of reservation price among all participating bidders. In particular, given heterogeneous holding horizons and private values toward home ownership, the key insight for (positive) return predictability is that, in expectation buyers face more competitive bids in the good market conditions and thus winners on average pay an amount closer to their own valuations at those times. That in turn translates into a higher (expected) transaction price in the good state. This is a novel asset pricing implication of market microstructure that has not been explored in the literature.

To fix ideas, I present a simple and stylized overlapping generations model in the context of the residential housing market. Assets of interest are in limited supply and I restrict the number of owner-occupied houses to be one in the model. Whenever the asset is available for sale, it is sold by the seller through a second-price sealed-bid absolute (no-reserve) auction. In each period, two types of risk neutral agents are born. They differ (i) in their asset holding horizons and (ii) in their tastes for the housing good. The short horizon type will live for one period and thus sell the asset in one period and the long horizon type will sell in two periods at the end of the cycle. In face of the uncertain macro fundamental and heterogeneous private values, the potential buyer's reservation price for ownership consists of two components. One is her willingness to pay for housing services (i.e. rental costs). The second component is the potential buyer's valuation for the expected resale price associated with home ownership. One type of agents might have a higher reservation price for the housing asset either because she has a higher rental valuation given by either a higher market rent or a higher private value for housing consumption, or because the expected capital gains is larger given her sale horizon.

If, instead of through an active bidding process with strategic interaction among each buyer group, the price is determined by market rental dividends based on the *expectation* over the i.i.d. idiosyncratic private consumption benefits for each buyer[1], the macro

[1]For example, this could be the case if there is a single price setter who does not observe buyers' private values and form valuations based on the expected values (i.e. the market rent). Alternatively the single price setter clears the market with one price, using aggregate demand and thus average out the idiosyncratic private values.

uncertainty (in the form of market rents) is fully capitalized in equilibrium and buyers' idiosyncratic private values do not affect the equilibrium prices in expectation. As a result, buyers with different holding horizons in expectation will have the same valuations and thus the turnover rate is unpredictable across states. However, equilibrium price has a different characterization in the presence of heterogeneous private values with active bidding. Intuitively, any type of owner's rental valuation now depends on her own private value. In addition, her resale option depends on the private values of prospective buyers in the future. Although long horizon buyers on average are willing to pay more for rental costs, long horizon buyers expect to pay on average a relatively lower rent next period compared to today if the current market rent is high. In other words, the two types of agents' rental valuations are closer in the good macro state compared to the bad state. As a result, the rental dividend component of the bid is more competitive in the good state and in general the winning buyer is paying an amount closer to her own valuation. In addition, a buyer's resale option is more valuable if she expects to sell in such a time when potential future buyers have closer valuations. Therefore, a buyer's expected resale value is higher if she expects to sell in a good market condition. Given a positively persistent macro fundamental, for a long horizon buyer, that corresponds to a purchase time in the bad state since states revert in the long run. Taken together, long horizon buyers are relatively paying more when they are buying in the bad macro state, both because their rental valuations are more dominant and their resale prospects are more attractive. Analogously, both of short horizon buyers' rental dividend valuation and their resale options are worth relatively more when they are buying in good times. Thus the short type buyers are more likely to win the asset in such times, conditional on the asset being available for sale.[2] Furthermore, if the underlying macro fundamental is positively persistent, that particular state-dependent ownership structure translates into higher expected turnover rates in good times and vice versa. The intuition is that short horizon winners in good times are also very likely to sell in good times, since good market conditions persist in the short term.

[2]Technically, in the second price private value auction considered here, the transaction price, which is distributed as the minimum of the long type's and short type's valuations, does not reflect the right tail of the higher bidder's valuation distribution. This particularly leads to the downward biased equilibrium prices in our setting (compared with the prices without the (second price) auction mechanism). However, the key insight that in good state long horizon buyers pay on average an amount closer to their valuations does not depend on the specific format of the auction. I discuss this in more detail in the model robustness section.

Using the model's asset pricing implications, I empirically identify asset owners' *ex ante* holding horizons as a factor to explain and predict asset price movements. Using data from the American Housing Survey, I find evidence consistent with the model's predictions. Using a censored normal regression on a pooled sample of nearly 9000 observations, I first estimate owners' *ex ante* holding horizons based on time-independent demographic and housing unit characteristics. This provides a measure of the expected ownership duration at the time of purchase given owners' demographic and socioeconomic backgrounds. According to the model, buyers of different expected holding horizons prevail in home auctions in different market conditions. Using the MSA-level average *expected* duration for home owners as the test variable, in the constructed panel data of around 120 metropolitan areas over a 20 year period, I find a strong negative co-movement between the expected duration series and house transaction prices at the MSA level. In words, the data suggests that new owners' expected holding horizons are longer at the same time when prices are falling. This relationship is statistically significant and robust to a vector of control variables including time and location fixed effects.

Then I exploit, from the model's prediction, the forecasting power of expected duration on future price returns. According to the model, rational agents "time the market" and short horizon agents buy when prices are expected to be good in the near future. Thus a lower expected duration this period should predict a positive subsequent price change. I find that the expected duration has a strong predictive power on the future price changes that are attributable to observed macro fundamentals. Conditional on the current price level, a 10% increase in the expected duration forecasts roughly a 0.2% decrease in the *growth rate* of predicted price changes. This effect is more likely to come from the mechanism proposed in this paper rather than from a speculative channel in which the return predictability by owners' holding horizons is due to non-fundamentals-related reasons. I also find some evidence that the expected duration in an area with both desirable amenities and supply constraints (San Francisco Bay Area) has a stronger forecasting power for future returns in that area. This is consistent with the model's implication that the effect should be greater in areas where active bidding is likely to be a dominant purchase mechanism.

The paper is organized as follows. Section 2 reviews the literature. Section 3 presents a stylized trading model in the auction framework with consumer heterogeneity and a time-varying macro fundamental. Section 5 describes the data and variables in the empirical test and then reports the empirical specifications and results. Section 6 concludes.

2 Literature Review

This paper contributes to the literature that explains the positive correlation between prices and volume in the housing market. In a utility-based framework, Stein (1995) proposes a static model that explains how down payment constraint can restrict homeowners' mobility when prices fall. The essential argument is a negative demand shock increases the number of constrained households given a binding down payment constraint, which in turn puts more downward pressure on prices and thus creates a multiplier effect. Ortalo-Magné and Rady (2006) build on Stein's insight and enriches the model in a life-cycle framework. However, empirical results on the down payment effect are mixed. While Genesove and Mayer (1997) lend support with data on the Boston Condo market, Engelhardt (2003) find much of the effect can be attributed to nominal loss aversion instead with a different data set. Lamont and Stein (1999) are unable to find strong support for the price effect when the sample is controlled for endogeneity and they do not address the question of the down payment effect on trading volume.

Motivated by housing asset's heterogeneity and substantial search frictions during the trade process, researchers explicitly model the role of search frictions in explaining housing market dynamics, starting from Wheaton's seminal paper in 1990. Particularly relevant to this paper is Krainer (2001) which exploits time varying search costs to explain the joint dynamics of price and liquidity. His intuition is that sellers face a trade-off between immediate sale and continued search. The benefits associated with continued search arise from the next buyer's possibly larger idiosyncratic match quality. Meanwhile, sellers incur time-varying costs of forgone rent by leaving the house empty on the market for another period. The latter implies that time-to-sale will be a function of macro conditions. As a result, his search model has implications on the time-varying time-on-the-market effects which my model is silent about.

In general, this paper complements the existing two strands of rational explanations in the context of residential housing market. Both approaches above invoke frictions in the market clearing mechanism that are specific to the housing market. On the contrary, my results suggest that the observed dynamics is likely to occur even when such market frictions are released. Indeed, I argue that it is likely to be a natural implication of an asset market traded by auctions in which consumer investors have private consumption values for the asset, heterogenous expectations about their holding periods and the associated macro fundamental is persistent.

This paper is also related to the speculation-based model on the joint price and turnover dynamics (Scheinkman and Xiong (2003)). Motivated by the seminal paper on heterogeneous beliefs and its effect on speculation (Harrison and Kreps (1978)), they focus on overconfidence as the source of heterogeneous belief. Ownership of the asset is granted with an American option to profit from other investors' overvaluation. In times where there exists overvaluation ("bubble"), the option will be exercised frequently and an increase in trading volume will endogenously arise. At the empirical front, Mei et al. (2005) and Wong (2007) find positive evidence for the theory in China's stock market and the Hong Kong residential housing market respectively. My model shares the same insight that buyers' willingness to pay includes a resale option component. However, agents are rational in my model and the heterogenous valuations are due to a combined effect of heterogeneous agents and the specific equilibrium price characterization under the auction mechanism. On the other hand, compared to their general context, this paper focuses on a narrower asset class.

Within the context of the residential housing market, there is another related behavioral explanation that focuses on the down side of the cycle in explaining the positive correlation. Motivated by the prospect theory by Kahneman and Tversky (1979), Genesove and Mayer (2001) formally test the idea that sellers's loss aversion when their house values experience an unrealized loss contributes to low trading volume in down markets. Engelhardt (2003) strengthens the previous paper's results by distinguishing the nominal loss aversion effect from the borrowing constraints effect.

As a paper using the auction mechanism, I depart from the auction literature in the sense that the latter mostly focuses on the question of what is the optimal mechanism design, either from the seller's or the social perspective. In the context of real estate, a large body of research has been done to either apply, extend or test the general auction theory in this particular market.[3] In contrast, this paper spells out some asset pricing

[3] For an extensive list of contributions, please see Quan (1994).

implications in a dynamic setting with an auction as the mechanism of price formation. Although the auction set up in this model is quite simple, the results suggest that this micro trade mechanism could have profound impact on equilibrium prices in a dynamic economy in the presence of heterogeneous agents and I also lay out some intuition for this result to be generalizable in a more sophisticated bidding environment. To some extent, this paper is related to Mayer (1995), which studies in a static framework the auction prices given different market conditions. In the co-presence of an exogenous match market in which sellers set the market price, buyers pay less for auctioned properties. In addition, the auction discount is higher in bust market since there are fewer bidders at that time leading to a larger difference in mismatch costs of the winning bidder. In this paper, on the other hand, an auction is the only trade mechanism. I obtain equilibrium prices in a dynamic setting and the asymmetric negative impact in different states is due to the fact that the relative valuation distribution among different types of buyers is asymmetric across time and buyers face more competitive bids in the good state.

3 The Model

In this section, I study a simple and stylized model of asset trading with housing as the asset in a two period overlapping generations model.

Agents

- Consumers: In each period, two agents are born in the economy. One lives for two periods (long horizon) and the other one lives for one period (short horizon). Agents are both risk neutral and maximize their life time utility with respect to a housing good and numeraire consumption. Both types of consumer buyers are financially unconstrained and they either bid to buy the owner-occupied house out of their wealth at the first period or live in the rental market and pay rents period-by-period.
- Landlords: There is a long-lived risk neutral landlord in this economy who does not consume housing and is passively collecting rents in the rental market.

Characterizing consumers into the long and short holding types is a parsimonious way to capture the feature in the housing market that buyers have different planning or life horizons.[4] Short horizon buyers could be driven by expected mobility needs or expected change in family structure or they are simply elderly people with a shorter life span left. Long horizon buyers could be younger in age or more settled-down in their career. To be more specific, I calculate from American Housing Survey's 2003 recent mover data and on average owners spend 8.17 years in their previous homes. However, 75% of owners live in their previous homes for less than 11 years. Among them, 50% of owners have a duration of only 3 years or less. This shows there is a great diversity of holding horizons for home owners. One caveat is that the realized duration will depend on *ex post* market conditions, but there is evidence in the residential mobility literature that the actual mobility behavior is driven largely by expected mobility, which in turn is a function of movers' socioeconomic characteristics such as age, marital and retirement status (Ioannides and Kan (1996), Kan (1999) and etc).

Assets:

- There is one unit of owner-occupied house which is indivisible and maybe available for sale at any time t. Upon purchase of the owner-occupied house, the owner has to consume the entire unit after she acquires the asset until the end of her horizon.
- There is also a rental market in fixed supply. As with the owner-occupied market, each renter consumes exactly one unit of rental housing and she also consumes the rental unit until the end of her horizon. For convenience, there are two units of rental housing in the economy so that the total number of units of housing equal the total number of consumers in this economy in a given period.
- Whether agents live in the owner-occupied market or the rental market, they need to pay for the housing services. The cost of housing services or the (implicit) rent per period at time t is exogenously given by $\eta_i Y_t$. Y_t is the common component of the rent process at time t and is driven by fluctuations in the macro economic

[4] This seems to be a different take from the traditional housing demand literature, in which household formation (and thus their expected duration) is an endogenous function of market conditions. However, I view the exogenously fixed holding horizon as the assumption conditional on the effect of market conditions on household formation. That is, given the prevalent conditions, I assume there is still cross-sectional heterogeneity in home buyers' *ex ante* holding horizon expectations, which are mainly driven by their demographic characteristics. Nevertheless, there remains the caveat that the holding horizon expectations might be systematically correlated with prevalent market conditions through the household formation channel. In the empirical section, I need to take that into account for test identification.

conditions. If consumers live in the rental market, they will pay Y_t as the rental cost. Thus Y can also be interpreted as the market rent. Y takes on two values Y_L and Y_H and its evolution follows a first-order Markov chain with the transition matrix defined as follows:

$$\begin{pmatrix} \lambda & 1-\lambda \\ 1-\lambda & \lambda \end{pmatrix}$$

When $0.5 < \lambda < 1$, the macro fundamental is persistent. High states are more likely to be followed by high states. If $\lambda < 0.5$, the macro fundamentals is more likely to switch between the states. And it is state-independent if $\lambda = 0.5$. This modeling approach is similar to Krainer (2001) and Sinai and Souleles (2005) where rents take on a persistent process.

Following Williams (1995) and Krainer (2001), in addition to the market rent, there is an idiosyncratic component η_i associated with home ownership that is specific to each consumer during her life cycle. This is to capture the feature that different buyers often have idiosyncratic tastes for the same house and thus are willing to pay different prices. η is an i.i.d. uniform random variable distributed on the support of $(1-\psi, 1+\psi)$. Thus the entire imputed rental dividend for owner-occupied house is a mean-preserving spread of the macro component Y. In short, the role of η is that in equilibrium the expected sale price not only is a function of the state-dependent macro fundamentals Y, but it also depends on the idiosyncratic component η.

- There is also a risk free asset that yields a rate of return of $r > 0$. In this model, r is a constant.

Information Structure: Every agent in the economy observes the macro component of the rental dividend process. The η realization for each agent, however, is purely private information.

Trade Mechanism: Conditional on the owner-occupied housing asset being available for sale, the seller will host a second-price sealed-bid absolute (no reserve) auction in which the highest bidder wins and pays the second highest bid. In the event of a tied bid, each of the highest bidders win with equal probability. Following Mayer (1995), I choose the second-price auction as the format, in which truth telling is a weakly dominant bidding strategy. Since in equilibrium, prices are a function of the macro fundamental

Y, this is an independent asymmetric private value auction, conditional on the level of Y.

Timing of Events and Information Arrival

- Two new agents (one short and one long type) are born at the beginning of time t.
- Every agent in the model observes the market rent Y_t.
- Every agent in the model observes her own idiosyncratic value η.
- Given the owner-occupied house is available for sale at time t,
  - potential buyers determine the reservation bidding price for the owner-occupied house and engage in the second price auction.
  - Winning bidder buys the owner-occupied house while the losing consumer goes to the rental market forever.
  - At the end of owner's horizon, she sells the house by hosting a second-price sealed-bid auction.
- If there is no owner-occupied asset on the market at time t, consumers all live in the rental market.

Equilibrium Prices and Turnover Rate

Lemma 1. *Conditional on the owner-occupied housing asset being available for sale at time t, consumers' equilibrium bidding strategy for the owner-occupied house can be characterized by the following reservation price pair.* $P_{s,t}$ *is the reservation price for the short horizon potential buyer and* $P_{l,t}$ *is the reservation price for the long horizon potential buyer.*

$$
\begin{aligned}
P_{s,t} &= \eta_s Y_t + \frac{1}{1+r} E_t[P_{t+1}], \\
P_{l,t} &= \eta_l Y_t + \frac{1}{1+r} \eta_l E_t[Y_{t+1}] + \frac{1}{(1+r)^2} E_t[P_{t+2}].
\end{aligned}
\tag{3.1}
$$

Proof. See Appendix. □

Recall that there will always be two consumers (with different horizons) bidding in this economy, conditional on the owner-occupied asset being available for sale. In a two-person auction game, the price is determined by,

$$\begin{aligned} P_t &= \min\big(P_{s,t}, P_{l,t}\big), \\ &= \min\big(\eta_s Y_t + \frac{1}{1+r}E_t[P_{t+1}], \eta_l Y_t + \frac{1}{1+r}\eta_l E_t[Y_{t+1}] + \frac{1}{(1+r)^2}E_t[P_{t+2}]\big). \end{aligned} \tag{3.2}$$

The equilibrium concept is steady-state stationary equilibrium, in which I seek equilibrium prices as a function of the macro states. That implies the expected future sale price is a probability weighted average of equilibrium prices associated with the two states. Note that the expected sale price in each macro state also depends on the idiosyncratic component η. In particular, future prices will also depend on future generations' preference for the housing good. In the steady-state equilibrium, I need to take into account of all possible realizations of η for all generations of buyers in an asymmetric auction problem. And for each bidder pair in equilibrium, they will take that expectation as the given equilibrium price associated with a particular state in order to determine their reservation values.

For notational convenience, I let $\psi = 1$ so that $\eta \sim$ Uniform(0,2).[5] It is clear that the lower support of potential buyers' reservation price is their expected sale price given their holding horizons. And I define the upper and lower support of potential buyers' reservation price, conditional on Y_t,

$$\begin{aligned} \underline{U_{s,t}} &\equiv \frac{E_t[P_{t+1}]}{1+r}, \qquad \overline{U_{s,t}} \equiv 2Y_t + \underline{U_{s,t}}, \\ \underline{U_{l,t}} &\equiv \frac{E_t[P_{t+2}]}{(1+r)^2}, \qquad \overline{U_{l,t}} \equiv 2(Y_t + \frac{E_t[Y_t]}{1+r}) + \underline{U_{l,t}}. \end{aligned} \tag{3.3}$$

In the steady-state equilibrium, I look for the equilibrium (expected) prices of the form P^H, P^L. Then the state-dependent equilibrium (expected) transaction prices of the

[5] We also compute the equilibrium using $\psi = 0.1$ and our result on positive correlation between turnover rates and prices carry through.

owner-occupied housing asset solve the following fixed-point problem,

$$\begin{aligned} P^L &= \int_{(lower^L(P^L,P^H),upper^L(P^L,P^H))} pdF_p(P^L, P^H), \\ P^H &= \int_{(lower^H(P^L,P^H),upper^H(P^L,P^H))} pdF_p(P^L, P^H), \end{aligned} \tag{3.4}$$

where F_p is the cumulative distribution function of the equilibrium price with support $(lower^i, upper^i)$ and $lower^i \equiv \min\left(\underline{U_{s,i}}, \underline{U_{l,i}}\right)$, $upper^i \equiv \min\left(\overline{U_{s,i}}, \overline{U_{l,i}}\right)$, $i = L, H$. In words, the two equations in (3.4) impose the equilibrium conditions that for a particular state, the steady state expected sale price in a particular macro state equals the winning buyer's paying price in expectation over all possible realizations of η for each type of potential buyers for that state, taking future sale prices as given.

In order to solve the stationary equilibrium prices P^L and P^H, I first observe that the equilibrium prices P will be linear in the macro fundamental in the current setting with two-state dynamics and risk neutrality. I then re-characterize the problem by defining p^L, p^H such that $P^L = p^L Y^L$ and $P^H = p^H Y^H$. p^L, p^H are essentially (expected) state prices for the owner-occupied housing asset and it is equivalent to solve the equilibrium by finding the state prices p. By so doing, the problem is reduced to finding a fixed-point in a static asymmetric auction problem with uniform private values.

Proposition 1. *The state prices p^L and p^H are the solutions to the following system of equations,*

$$\begin{aligned} p^L &= \int_{(lower^L, upper^L)} pdF_p^L, \\ p^H &= \int_{(lower^H, upper^H)} pdF_p^H, \end{aligned} \tag{3.5}$$

where F_p is given by,

$$\begin{aligned}
F_p^L &= [\frac{p - lower^L}{(\overline{u_s^L} - \underline{u_s^L})I_{\underline{u_s^L}=lower^L} + (\overline{u_l^L} - \underline{u_l^L})I_{\underline{u_l^L}=lower^L}}] I_{p\in[lower^L, \max(\underline{u_l^L}, \underline{u_s^L})]} \\
&+ [\frac{p - \underline{u_s^L}}{\overline{u_s^L} - \underline{u_s^L}} + \frac{p - \underline{u_l^L}}{\overline{u_l^L} - \underline{u_l^L}} - \frac{(p - \underline{u_l^L})(p - \underline{u_s^L})}{(\overline{u_l^L} - \underline{u_l^L})(\overline{u_s^L} - \underline{u_s^L})}] I_{p\in[\max(\underline{u_l^L}, \underline{u_s^L}), upper^L]}, \\
F_p^H &= [\frac{p - lower^H}{(\overline{u_s^H} - \underline{u_s^H})I_{\underline{u_s^H}=lower^H} + (\overline{u_l^H} - \underline{u_l^H})I_{\underline{u_l^H}=lower^H}}] I_{p\in[lower^H, \max(\underline{u_l^H}, \underline{u_s^H})]} \\
&+ [\frac{p - \underline{u_s^H}}{\overline{u_s^H} - \underline{u_s^H}} + \frac{p - \underline{u_l^H}}{\overline{u_l^H} - \underline{u_l^H}} - \frac{(p - \underline{u_l^H})(p - \underline{u_s^H})}{(\overline{u_l^H} - \underline{u_l^H})(\overline{u_s^H} - \underline{u_s^H})}] I_{p\in[\max(\underline{u_l^H}, \underline{u_s^H}), upper^H]}. \qquad (3.6)
\end{aligned}$$

In addition, $upper^i = min(\overline{u_s^i}, \overline{u_l^i})$, $lower^i = \min(\underline{u_s^i}, \underline{u_l^i}), i = L, H$ and with $y \equiv Y^H/Y^L$, I have

$$\begin{aligned}
\underline{u_s^l} &= \frac{1}{1+r}\big(\lambda p^L + (1-\lambda)p^H y\big), \overline{u_s^L} = 2 + \underline{u_s^l}, \\
\underline{u_s^H} &= \frac{1}{1+r}\big(\lambda p^H + (1-\lambda)p^L \frac{1}{y}\big), \overline{u_s^H} = 2 + \underline{u_s^H}, \\
\underline{u_l^L} &= \frac{1}{(1+r)^2}\big((\lambda^2 + (1-\lambda)^2)p^L + 2\lambda(1-\lambda)p^H y\big), \overline{u_l^L} = 2 + 2\frac{1}{1+r}\big(\lambda + (1-\lambda)y\big) + \underline{u_l^L}, \\
\underline{u_l^H} &= \frac{1}{(1+r)^2}\big((\lambda^2 + (1-\lambda)^2)p^H + 2\lambda(1-\lambda)p^L \frac{1}{y}\big), \overline{u_l^H} = 2 + 2\frac{1}{1+r}\big(\lambda + (1-\lambda)\frac{1}{y}\big) + \underline{u_l^H}.
\end{aligned} \qquad (3.7)$$

Proof. See Appendix. □

The system of equations in (3.5) has no closed form solutions. However, numerical analysis is easy and straightforward. I start with a pair of guesses for the state prices p^L, p^L and numerically integrate the RHS of (3.5). The equilibrium state prices obtain when the deviation of the calculated integral from the guessed value is smaller than a pre-set tolerance level.

In order to understand the turnover rate of the owner-occupied housing asset in this set up, I need to compute the winning probability (conditional on the asset being available for sale) for each type of buyer in each state of nature in equilibrium. Notice that given the equilibrium prices p^H, p^L, the two types of bidders will form expectation of their future resale prices. The resale prices are different between the two types given their different holding horizons. Then the conditional winning probability of one type in a given state corresponds to the probability that her total rental costs outweigh the other type's rental costs by an amount at least as large as the resale prices' differences between them. Mathematically, I have the following proposition.

Proposition 2. *Let $u_j^i = \overline{u_j^i} - \underline{u_j^i}, i = L, H; j = s, l$. Also define the two types' difference in the capital gains component as $g^i, i = L, H$. Denote $g^L \equiv \frac{1}{(1+r)^2}\big((\lambda^2 + (1-\lambda)^2)p^L + 2\lambda(1-\lambda)p^H y\big) - \frac{1}{1+r}\big(\lambda p^L + (1-\lambda)p^H\big)$, and define g^H similarly. Given equilibrium state prices p^L, p^H, the expected winning probability for agent j (j=s,l) at state i (i=L,H) conditional on asset being available for sale is given by,*

$$
\begin{aligned}
Pr_l^i &= \frac{1}{u_l^i}\int_0^{\min(u_s^i, u_l^i + g^i)} \frac{u_l^i - \max(x_s^i - g^i, 0)}{u_s^i} dx_s^i + \frac{\max(g^i, 0)}{u_s^i}, \\
Pr_s^i &= 1 - Pr_l^i.
\end{aligned} \tag{3.8}
$$

With that, the expected turnover rate in the steady state is given by,

$$
\begin{aligned}
Q^L &= \frac{(1-\lambda)Pr_s^H + 2\lambda(1-\lambda)Pr_l^H}{(1-\lambda)(Pr_s^L + Pr_s^H) + 2\lambda(1-\lambda)(Pr_l^L + Pr_l^H)}, \\
Q^H &= \frac{(1-\lambda)Pr_s^L + 2\lambda(1-\lambda)Pr_l^L}{(1-\lambda)(Pr_s^L + Pr_s^H) + 2\lambda(1-\lambda)(Pr_l^L + Pr_l^H)}.
\end{aligned} \tag{3.9}
$$

Proof. See Appendix. □

I show equilibrium expected transaction prices, the expected turnover rate as well as the expected winning probabilities in the following figures. Fig. 2 shows both the expected price and the expected turnover rate in the steady state equilibrium for $\lambda \in (0, 1)$. Equilibrium prices are higher in the high state than in the low state, implying serial correlation given a serially correlated fundamentals Y. For the expected turnover rate, it depends on the persistence parameter λ. If the macro fundamental is persistent, meaning $\lambda > 0.5$, the expected turnover rate is higher in the high state. On the other hand, if macro fundamentals are more likely to switch states ($\lambda < 0.5$), I get the opposite result. In summary, I obtain positive co-movement between price and turnover when the macro fundamental is of a (positive) persistent nature.

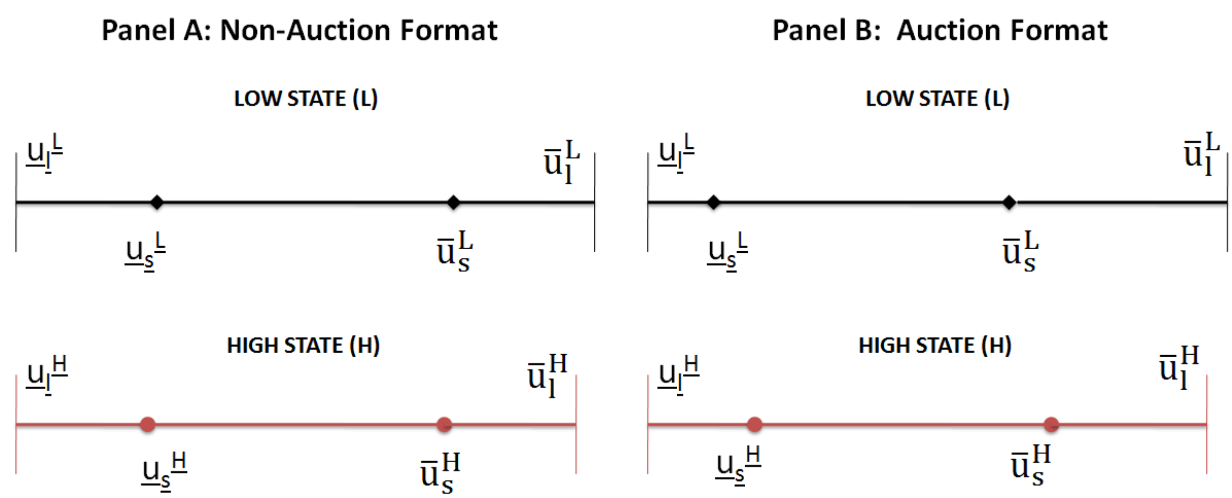
Proposition 2 suggests that the correlation structure between the expected price and turnover rate across states is determined jointly by the dynamics of the macro fundamental Y and the two types' state-dependent conditional winning probabilities. Thus I plot in Fig. 3 the short horizon buyer's conditional winning probabilities across states as a function of λ. Short horizon buyers in general have a higher conditional probability of winning the auction in the high state than in the low state. Given that ownership structure, it is straightforward to see the intuition behind the pattern of the turnover rate. If the macro fundamental is persistent, the fact that more short horizon bidders buy in good times also implies by the time they sell, with high probability the economy is also in the good state. Similarly, when long horizon types are more likely to become owners in the bad state, they are less likely to sell in a bad state since bad shocks die away in the long term. In sum, that translates into a higher turnover rate in the high state and a positive correlation between prices and turnover rates. On the other hand, if the macro states are of a switching nature, the exact opposite will happen. The short horizon buyers purchase at the high state but are more likely to sell in the low state, while the long horizon bidders buy at the low state and also are likely to see in the low state, leading to a higher turnover rate in the low state.

Regarding the state-dependent winning probabilities for each type of agents (conditional on the asset being available for sale) as in Fig. 3, I argue it is a combined result of both the total rent process ηY and the bidding mechanism. First, one can show that in the presence of only the macro component Y, with a positive interest rate, the only sustainable equilibrium price pair is one such that both types of bidders have the same equilibrium bidding prices. The intuition for that is that rental costs are fully capitalized in equilibrium. As a result, the turnover rate is unpredictable in this equilibrium. Secondly, it is also the case that if the equilibrium price remains the same in the presence of i.i.d. idiosyncratic consumption benefits η,[6] each type of bidders in expectation still has the same probability of winning (0.5) for each state. Panel A in Fig. 1 below shows the two types' valuation distributions under this pricing scheme. The short horizon type's and the long horizon type's valuations are both distributed as uniform random variables, conditional on the level of the macro fundamental Y. In both states of the world, the entire line represents the support for the long horizon buyer's valuation, conditional on the equilibrium prices described above. The short horizon buyer's valuation distribution

[6] That is the case, for example, if the price is determined by a single price setter who does not observe the ηs and thus derive equilibrium prices based on the market rent.

lies within that of the long horizon buyer. It has a larger lower (or left) support which reflects the short horizon buyer's larger discounted present value of resale price. The upper support of the short type's distribution is smaller since the short type's rental costs are on average smaller given the shorter horizon. It is clear from the diagram in Panel A that with this set of equilibrium prices the short and the long types have the same conditional winning probabilities in both states (as $\underline{u_s^i} - \underline{u_l^i} = \overline{u_l^i} - \overline{u_s^i}$, $i = L, H$ in this case). This result is quite intuitive. If the systematic rents are entirely capitalized into equilibrium prices, adding i.i.d shocks ex post is simply adding noises and in expectation each type of agents still has the same valuations and thus the same winning probabilities.

Fig. 1: Equilibrium Valuation Distribution of the Two Types



The diagrams illustrate the distribution of the two types' valuation in equilibrium when prices are determined differently. Panel A (on the left) shows the distributions when prices are determined based on the *expectation* of private consumption benefits (i.e. market rent). Panel B (on the right) shows the equilibrium valuation distributions for the two types when buyers bid their true (idiosyncratic) values. Note the unit in the high state case is scaled by the level of Y. In both panels, the diagrams are created using $\lambda = 0.95$, $r = 0.1$,$Y^H/Y^L = 2$,$\phi = 1$.

However, given the bidding mechanism, the equilibrium price is derived as the expectation of the *minimum* of the two buyers' bidding prices. Thus in general it has a (downward) deviation from the equilibrium price above, which is obtained in the non-auction context. That leads to a wedge between the two types' reservation price (even in expectation) in equilibrium. In addition, observe that the distribution of the minimum of the two types' valuations is truncated (on the right). In words, higher valuations of rental costs tend *not* to be reflected in the equilibrium prices. On average long horizon buyers have higher rental costs and the rental cost differential is especially larger in the bad time. Observe in both panels of the figure above, the distribution of the long horizon type is more dispersed in the low state. This is because if the current state is low, future expected rental cost will be higher than today's. On the other hand if the current state is high, long horizon buyers expect to pay a lower rent in the next period. That implies that winners on average pay an amount closer to their own rental valuation in the good state. On the contrary, winners expect to pay an amount much less than their true valuation if they buy at a bad state. Thus the deviation in the equilibrium auction price has a larger (negative) impact on the price in the low state. If the macro fundamental is persistent, this makes the short horizon owner's resale option relative to that of the long horizon owner's more valuable in the good time. In such times the short horizon buyer expects a much larger resale price relative to the long horizon buyer, if price in the low state is particularly "bad". Panel B in the figure above illustrates the effect of the auction mechanism. In general, the distribution of the short type's valuation (relative to the long type's distribution) shifts to the left, implying short horizon buyers on average win less given smaller equilibrium prices. However, it shifts to the farther left in the low state, leading to an even smaller probability of short type owners in bad times than in good times. Intuitively, given a positively persistent nature of the macro fundamental, bids for the same house in the good times are more competitive since short type's rental valuations is on average closer to the long type's rental valuation and short type's expected resale price is relatively more attractive at such times.

Another good example to understand the mechanism is to look at the conditional winning probability when $\lambda = 1$ (Fig. 3). The equilibrium price is smaller by nature of the second-price auction format. That means on average short horizon buyers win less with the expected winning probability smaller than 0.5. In addition, there is no macro uncertainty. The direct implication is that on average rental cost differential is the same across states. As a result, the impact on equilibrium prices and winning probabilities is symmetric. Therefore, the winning probabilities of each type is the same for the two states.

4 More Discussion on Model Robustness

4.1 Auction Assumptions

The model's result on the state-dependent turnover rates depends on the fact that the equilibrium price is a biased estimator of the expected reservation values for all buyer pairs. Furthermore, its impact on equilibrium prices and winning probabilities is asymmetric across states. It is quite clear that this is a feature that is due to having active bidding as the mechanism for price formation. There are a couple of concerns regarding the specific auction set up in my model. The first is on the assumption of the number of each type of bidders in the model. If there are multiple bidders of each type in the model, the result on asymmetric price impact cannot be directly applied. However, the set up with one two-holding-period buyer and one one-holding-period buyer is parsimonious in order to capture the flavor of effects of different holding horizons with technical tractability. Realistically, it is more plausible that each buyer's holding horizon is distinct in the presence of more than two bidders. In that case, as long as the underlying macro fundamental is time varying, there will still be the wedge in buyers' total rental costs in different times. And on average winners will pay a higher price (closer to their true valuation) in good times. Thus I still expect an asymmetric impact on equilibrium prices in different market conditions. The other question is whether the result is sensitive to the auction format, where the winner pays the second highest valuation. This by definition directly leads to a *right* truncation on the equilibrium transaction price distribution. It brings the question of whether the result holds if instead the first-price sealed-bid auction is used as the mechanism. I argue that although the maximum statistics used in the first price auction does not truncate the right tail, ex ante bidders bid much less than her *true* valuation. This is because in the first price auction, bidders will infer about the second highest bidder's valuation and shade their bidding price accordingly. And bidders with a larger upper support of their private values shade considerably more than the bidder with a smaller upper support, which suggests that in equilibrium winners still pay more in the good state with a first price auction format.

4.2 Asset Supply

The key insight of the model is that the agents who place the greatest value on the asset get to own it and the heterogenous valuation is tied with the different resale prospects (relative to rental cost) in different states. This implies that the condition that the asset is in limited supply is crucial. An extreme counter example is a case that there are exactly the same number of assets with the number of potential buyers. And if the asset is homogeneous, every agent is indifferent with the particular asset she buys. In that world, there is no bidding problem. Even if agents pay their true reservation prices, the state-dependent ownership structure will depend on the proportion of short versus long horizon buyers and it is not clear that the model's result will sustain. However, within the context of the housing market, it is well-known that land is a scarce resource and is in limited supply. Furthermore, asset heterogeneity is another important feature of the owner-occupied housing assets. For example, every house differs in location. Even in areas with abundant land, there is still a limited number of houses with desirable features such as location and access to amenities. In sum the bidding problem will still be an important characterization of the housing asset market transactions. This discussion also gives an empirical prediction that the mechanism is better manifested in areas with supply constraints and/or areas with desirable natural amenities (e.g. coastal areas).

5 Empirical Evidence

The model points to the time varying ownership duration as the channel driving the positive co-movement between price and volume. This directly provides one hypothesis for the empirical test. That is, I expect to see new home owners' *expected* duration to decrease as the macro conditions improve. In other words, the expected duration of home ownership *at time of purchase* should be negatively correlated with the prevailing macro conditions and prices. In addition, my model suggests that at the time of purchase rational buyers time the market and thus new owners' *ex ante* investment horizons predict future returns.

5.1 Data

In this analysis, I use data from American Housing Survey. Starting from the 1970s, the survey is conducted by the Bureau of the Census for the Department of Housing and Urban Development (HUD). The American Housing Survey (AHS) collects data on the Nation's housing, including apartments, single-family homes, mobile homes, vacant housing units, household characteristics, income, housing and neighborhood quality, housing costs, equipment and fuels, size of housing unit, and recent movers. National data are collected in odd numbered years, and cover an average 55,000 housing units. It has the longitudinal design since the AHS returns to the same housing units year after year to gather data.

I collect the biennial data from the national sample from 1985 to 2005. For each housing unit in sample, I identify every owner during those twenty years along with his/her socioeconomic characteristics such as age, sex, race, marital status, family size, income, education, owner status(fist time) and mortgage characteristics. In addition, I collect the physical characteristics specific to each housing unit–type of housing unit, unit square footage, number of rooms, current value, last transaction price as well as its MSA code.[7] For my purpose, I drop observations in which the housing unit is not owner-occupied. I confine my sample of owners with age greater than 25 at time of move-in date, since a younger age implies that ownership is more likely to be by means other than purchase. I focus on home purchases that occurred after year 1970 since data is limited for purchases made before 1970 and I also suspect the measurement error is larger for those observations. I also drop households with missing (or obviously wrong) move-in dates and those that lie outside the MSA area. I convert the dollar value of income and house price into real terms (in 2006 dollars) using consumer price index from the Bureau of Labor Statistics. The final pooled sample consists of 12165 owner observations with *purchase* years ranging from 1970 to 2005. and the summary statistics is presented in Table 1. Note the summary statistics is based on the variable values at the purchase year for each owner observation, which is a sub-sample of the entire owner-unit observations. Since ownership duration is the key variable of interest, I manually calculate it for each owner of each housing unit as the difference between the move-in dates of consecutive owners. My tests also require a measure of macro conditions at the MSA level. I compute

[7]In AHS, metropolitan areas are categorized by the 1980 PMSA definition.

and use the MSA level household income, unemployment rate as well as other aggregate demographic variables by year from Current Population Survey. I also obtain the 10 year constant-maturity bond yield as interest rates from the Global Financial Database. Consumer Price Index data is from the Bureau of Labor Statistics.

5.2 Empirical Specification

In order to test the hypothesis of my model, I need to construct a measure of the *ex ante* holding horizon for a home owner at the time of purchase. Although I do observe *realized* durations from the AHS survey, there are several problems with using them directly. First of all, realized holding horizons are affected by a number of factors that are unknown ex ante. For example, owners are forced to move due to an unexpected change in job or family status. Furthermore, realized durations will be affected by the *ex post* unexpected market conditions. Secondly, many of the observed durations in the sample are censored. From Table 1, 2/3 of the observations are censored since I only observe home ownership status until year 2005. In sum, realized duration as observed in the sample will be biased and inconsistent. As a result, the first step of my empirical test is to form an estimator taking into account these issues.

Motivated by the empirical evidence (Kan (1999)), I model the expected duration for each homeowner as the projection of the observed duration on a vector of demographic and housing unit specific characteristics at the time of the purchase. Specifically, expected duration for owner i $d_i = E[D_i^*|X_i]$, where D_i is the observed duration for i and X_i is a vector of explanatory variables. In the absence of censoring, d_i can be directly estimated using an OLS or a simple MLE specification. I handle the censoring problem by censored maximum likelihood estimation. The true realized duration is given by D^*, and

$$D_i^* = X_i\beta + \epsilon, \epsilon \sim N(0, \sigma^2).$$

I only observe,

$$D_i = \begin{cases} D_i^* & if c_i = 0 \\ D_i^c & if c_i = 1 \end{cases}$$

where c_i is a censoring indicator. Then the likelihood function for owner i is given by,

$$L_i = \left[\phi(\frac{D_i - X_i\beta}{\sigma})\right]^{1-c_i}\left[1 - \Phi(\frac{D_i - X_i\beta}{\sigma})\right]^{c_i}, \tag{5.1}$$

where $\Phi(\cdot)$ and $\phi(\cdot)$ are cdf and pdf of standard normal distribution respectively. The log likelihood is then given by $\sum_i^N lnL_i$, which is maximized with respect to (β, σ).

The predicted value (i.e., $\tilde{d_i} \equiv X_i\beta$) is my estimate for the expected duration for owner i. Note that the key variable of future tests are estimated in the first stage, my statistical inference in later tests is inevitably subject to the errors-in-variables problem. In particular, the conventional way of calculating standard errors may be misleading given I have estimated regressors. I treat this problem in two ways. First, I perform tests based on the average expected duration of owners in a given MSA area in order to minimize the effect of estimation imprecision on the expected duration. This can alleviate but not eliminate the problem, and I will as a robustness check adopt bootstrapping methods and obtain confidence intervals for the standard errors in later tests.

Then I proceed to the main test of my hypothesis. The first test is to see whether there is correlation between the average expected duration at time of purchase and the macro conditions at that time. I compute the average expected duration for a given purchase year at the MSA level. For macro conditions, I use the MSA level average household income and unemployment rate from CPS as well as nation wide interest rates and inflation. I expect, using implications from my model, that the local income levels should be negatively correlated with the expected durations since short horizon buyers tend to become owners when macro fundamentals are high. Unemployment is another extreme case of bad income shock and a higher unemployment rate implies a more (severe) negative shock, which should be associated with the expected duration in a positive fashion. Although stochastic interest rate is not explicitly modeled in this paper for simplicity, it is an important factor in determining buyers' reservation value and housing prices. My mechanism implies that with a persistent interest rate process, discounted rental costs are also likely to be persistent and short buyers will have a higher valuation in low interest rate environments. Thus I expect the correlation between expected duration and interest rates to be positive. Note that most of these macro variables have a strong time trend, so regressing on the level will in general lead to incorrect inference. I deal with this issue by using the differenced values on both sides of the equation. Econometrically, the test takes the form,

$$\Delta_{t,t-1}\overline{\tilde{d}_j} = \gamma\Delta_{t,t-1}z_j + \eta, \tag{5.2}$$

where $\overline{\tilde{d}_j}$ is the average predicted duration (in log terms) in area j and z_j are the corresponding macro conditions for area j.[8]

The second specification I employ to test the model is to exploit the implication that the endogenous housing prices will be persistent as well. That suggests that the expected duration should co-move *negatively* with house prices. In fact, home buyers do not care the general economic conditions per se. Instead they are particularly concerned with those macro fundamentals that will be projected into the house prices. Although a priori there are some candidates of macro variables that are important determinants of house prices, those are subject to measurement error in general. In addition, I do not observe the entire list of pricing factors and the test using directly macro variables will inevitably have omitted variable problems. Using the actual price data could avoid or alleviate such problems. In other words, observed housing prices should be a sufficient (at least a better) statistics to test my model. Thus in the second set of tests, I first check whether such a (negative) relation between expected duration and price exists. After that, I perform a stronger test. That is, my model does not only imply the existence of correlation between price and expected duration, but it also suggests that the current expected duration has forecasting power for future price changes. Mathematically, the test takes the following forms,

$$\Delta_{t+1,t}\overline{p_j} = \xi\overline{\tilde{d}_{j,t}} + \eta v_{j,t} + \nu, \tag{5.3}$$

$$\Delta_{t+1,t}\overline{\tilde{p}_j} = \tilde{\xi}\overline{\tilde{d}_{j,t}} + \tilde{\eta} v_{j,t} + \tilde{\nu}, \tag{5.4}$$

where $v_{j,t}$ is a vector of control variables and $\overline{p_j}$ is the average transaction price in area j for a given year, which I also compute from AHS. Equation (5.3) tests whether ξ is different from zero, i.e., whether expected duration can predict future price changes in that area. However the observed price changes will have a component that is pure shock and not predictable by macro fundamentals. Thus I also perform a test in equation (5.4), where $\overline{\tilde{p}_j}$ is the predicted price change in area j using observable macro variables. My model implies the forecasting power of expected duration should be with respect to the

[8]For later tests, I use the logged values as regressors for all variables in levels.

predictable component of the price changes, thus I expect (5.4) to be a more powerful test. In addition, (5.4) can also help to distinguish my mechanism from a speculation story. If the forecasting power of the current expected duration solely arises from a speculative channel through which non-fundamentals-driven speculators quickly flip the property and bid up the prices, one should expect the coefficient $\tilde{\xi}$ to be zero.

5.3 Results

Estimation results for the expected duration are shown in Table 2. Predictors of the expected duration include owner's age, gender, race, educational status, first time homeowner status, property for investment indicator, type of housing unit, building characteristics means of down payment and LTV.[9] I reproduce using this data set the usual findings of the expected duration, which is increasing in age (but decrease once retirement age is reached) and decreases in educational attainment. I also find that the expected duration is increasing in the size and quality of the house or neighborhood, which are quite intuitive. Although a very small fraction of the owners in sample use the property for pure investment purpose, the investment indicator has a significantly negative effect on the expected duration. First-time home buyers have a relatively shorter expected duration at time of purchase, which is consistent with a property ladder argument. I also include measures of owners' financing for the home purchase, including their major sources of down payment and loan-to-value ratio. This is first to control for the effect of borrowing constraints on mobility, as highlighted in Stein (1995) and Ortalo-Magné and Rady (2006). In particular, according to their mechanism, realized duration is longer in bad market conditions in the presence of borrowing constraints. As a result, the estimated expected duration could be large in bad times through this channel. In addition, since the mortgage financing is become more affordable over time, people are more mobile over time. Thus not controlling for owners' financing characteristics leads to a decreasing estimated expected duration over time, which could also mechanically generate a negative correlation with prices. The coefficient of LTV says that owners borrow more and also move more often, which indeed is consistent with the increasing mortgage affordability argument.

[9] I omit marital status and family size which are potentially important determinants of duration. That is because given the data, those two variables are only observed at the time of survey but not at the actual time purchase.

Notice that I mainly rely on predictors such as owners' demographic and the unit-specific characteristics. In sum, in this first stage of estimation, I am essentially imposing the condition that expected duration is only a function of time-independent household characteristics. In other words, two households should have the same *ex ante* horizon of stay even if one purchase in year 1985 and the other in year 1995, conditional on the same demographic characteristics. There are other variables which potentially are important determinants of expected duration and I intentionally leave them out. For example, cohort effect might be an important driver of different ownership duration in addition to the age effect. However, I choose not to incorporate a time fixed effects in this estimation since the purchase year fixed effect might also pick up any other time related factors independent of owners' expected duration, which in turn will bias the inference later. The other practical reason is that any fixed effects will put the normality assumption to question and the estimator of the expected duration is less reliable. Furthermore, I believe the omitted variable bias is less of a problem for my purpose for several reasons. First, I pick up part of the cohort effect through the education variable. Second, it is true that the omitted cohort effect might lead to a systematic bias of the expected duration estimate. However, the systematic shift in the estimate does not necessarily affect the correlation test (5.2) that is based on differenced values. In addition, I suspect the cohort effect is likely to be positively correlated with regressors in the censored MLE (such as educational variables), in which case the expected duration measure is biased upward. Later when I test the forecasting relationship, this upward bias in the expected duration measure in general suggests the coefficient will be also biased upward. This, together with the attenuation bias caused by measurement error in the estimate, will make it harder to find a negative forecasting relationship.

That said, there is a selection bias problem here since only those owners with abnormally long durations enter my sample for purchases prior to 1985, the starting year of the survey. In order to control for that, I first include a dummy variable that takes 1 if the purchase is before 1985 in the MLE of expected duration estimation. Later when I run formal econometric tests, I drop observations before 1985 in one specification as a robustness check. I also try to minimize the errors-in-variables bias on the standard errors in my tests caused by estimated regressors by bootstrapping methods. The other concern is that although I try to be careful not to choose any time varying predictors for the expected duration, I might still pick up some factors that co-vary with macro conditions and house prices. In later tests, I will put more control variables in the regressions.

I plot the graphs of the average predicted duration against the average observed duration for the entire United States from 1985 to 2005 in the top panel of Figure 4. The censoring problem of the observed duration series is quite obvious: the duration is decreasing at a fast space and it goes to zero as we approach year 2005. For the predicted duration series, for years after 1985, there is no (or less) obvious time trend for the expected duration series. However, there are fluctuations in the expected duration over time, which corresponds to a changing owner characteristics according to the estimation. Even at the national level, there is a bit of evidence of changing owners' characteristics that tracks macro economic conditions. For example, the expected duration decreases until 1990 and slowly climbs up until 1995 and this period happens to coincide with the real estate bust period. For better illustration, I also plot in the bottom panel of Figure 4 the expected duration series against the real HPI index over the same time. As the model predicts, the two series are negatively correlated especially after year 1990 (although the expected duration series is quite noisy compared to the price index series). To further exploit the graphical representation, I make another comparison between the national average expected duration and the same measure in Northern and Southern California that includes the San Francisco Bay Area and LA and its surrounding areas. Those areas are densely populated with desirable amenities and bidding is arguably a more representative purchase mechanism. According to the model, one should expect to see a stronger correlation in such areas. Indeed, as shown in Figure 5, the increase in expected duration in the early 1990s is much sharper for that part of California. Given that the expected duration is estimated with pure owners' demographic characteristics (so by definition it is a noisy measure), this provides the first piece of crude evidence for the model.

The graphs suggest that the mechanism in my model is plausible, however, one cannot make a conclusive inference without formal econometric tests. The first econometric test is to check if there is statistical correlation between the MSA average expected duration and the macro variables. Table 3 presents the results. I present the results with the whole sample (1970-2005) in the first four columns. The first two columns test the correlation with macro variables and the next two columns use the price data. In the columns (5)-(9), I test the same specifications using the sub-sample from 1985 to 2005. In general, I find some relationship between expected duration changes and macro variables' changes as my model suggests (column (2) and column (6)), however, the coefficients of those variables variables are never statistically significant throughout the specifications. Then I test the correlation using average house prices as the independent variable.[10] As expected, this specification is a more powerful test and the average expected duration changes do co-vary negatively with average house prices within an MSA. This result holds through all specifications and is robust to the two different sample period specifications. In column (9), I also add more variables to control for any time-varying component in the expected duration measure that may mislead the interpretation of its correlation with prices. In particular, I put in (changes of) the aggregate demographic trends including the proportion of households in a given MSA that are homeowners, college graduates, married, middle-aged (40-65) and old (> 65). Any of the above variables might have influence on both prices and expected duration. The incorporation of these additional control variables does decrease the price coefficient from -0.067 to -0.041 but the correlation remains statistically significant at the 5% level. In summary, results in this table confirm statistically the negative correlation as in the graphs.

In order to explore further, I then test a stronger prediction as in (5.3) and (5.4) and the results are in Table 4. In this set of regressions, I focus on the sub sample after year 1985. The model predicts the current expected duration should have forecasting power on future price changes, especially the portion that is predictable by current macro fundamentals. Regressing the observed price changes on lagged expected duration (column (1)-(4)) consistently yields a negative coefficient when I gradually add more control variables. However, the coefficients are not statistically significant. It could be that the estimated expected duration is likely to have a positive measurement error (given the discussion above), which makes the coefficient here also biased upward. This is also plausible if a large portion of the price change are pure shock and thus unforecastable. Then in column (5)-(7) I use the predicted price change as the dependent variable and test whether expected duration has forecasting power for the predicted component of price change. I obtain the predicted price change by projecting the observed price change on a set of macro variables.[11] The forecasting power in terms of the coefficient on lagged duration becomes statistically significant at the 1% level. It is also economically significant

[10]The average price variable is defined as the average transaction price for all observed sales for a given purchase year in an MSA from the American Housing Survey.

[11]I use lagged MSA level income,lagged unemployment, a set of lagged demographics , lagged price, lagged interest rates and inflation measures (CPI) as the explanatory variables. The R^2 in the regression is 40%.

as conditional of the price level, a 10% increase in the expected duration forecasts a 0.5% decrease in the growth rate of predicted price changes, controlling for size effects and MSA fixed effects (column (5)).[12] In column (7), I incorporate more control variables. The worry is that the expected duration measure obtained in the MLE potentially picks up some time-varying component. Then I cannot credibly attribute the forecasting power to the true intrinsic duration. In particular, in the estimation of the expected duration, I find owners' socioeconomic variables are important determinants of expected duration. Therefore, I specifically control for the aggregate demographic and socioeconomic trend for all households at the MSA level. As expected, the predictive power of the expected duration decreases from -0.053 to -0.017 in column (7), suggesting that quite a big chunk of the original forecasting power is indeed due to the aggregate trend in the demographics. However, there is still some independent forecasting power of the expected duration and the effect remains statistically significant at the 1% in column (7).[13]

As mentioned before, the tests are subject to errors-in-variables problem by using estimated variables as explanatory variables. Performing the regression on the average value in an MSA can only alleviate the problem since there might be only a couple of observations for a given MSA at one purchase year. Therefore, I adopt bootstrapping methods to the forecasting regressions in order to obtain a confidence interval for the standard errors of key variables of interest. The confidence interval result is in square brackets under robust standard errors in Table 4. For the key variable of interest, $\overline{\tilde{d_{t-1}}}$, the confidence interval is in general pretty tight. Especially for column (5)-(7), the highest standard error in this confidence interval decreases the t-statistics but in the worst case the statistical significance will remain at the 10% level.

Although this presents a stronger piece of evidence than the correlation regression above, it still cannot fully distinguish from other channels that produce a negative relationship between the duration measure and prices. For example, one concern is that from my estimation of the expected duration, long duration households are associated with

[12]The size variable, used in the regression in column (5) is defined by the average square feet per house (in log term) traded in a given MSA at the purchase year. This is to control for the change in the size of the house being traded in different years.

[13]One might notice that the R^2s in column (5)-(7) are astonishingly high. Recall these are regressions of the *predicted* price changes based on observable macro variables. Specifically, the R^2 in the first stage regression where we predict the price is 40%. One way to interpret is that the given independent variables in column (5)-(7) explain nearly 40% of the total price changes, conditional on the current price level.

minority and less educated people, who might only be able to afford to become home owners when prices are low. This is one channel that can also generate the negative relationship independent of my model's mechanism. In an effort to make the distinction, I further exploit my model's prediction. As argued, the model implies that the predictive power should be stronger in areas with supply constraints and where bidding is more prevalent in the purchase process. This first provide an additional empirical test of my model. In addition, in areas with limited supply, it is not obvious that when prices fall, on the margin more of the previously priced-out households become owners. That is because when supply is constrained, on average the poor (or priced-out) households can only own by buying from previous owners who are presumably richer. If there is not a systematic out-migration of richer households exactly when prices are low, I expect the mechanism above (that is different from mine) to be not or less effective in areas with supply constraints. We exploit this distinction by adding an interactive term of the expected duration with an area dummy that takes one for the San Francisco Bay Area. In general, the interactive term has a negative coefficient and especially so in the regressions of observed price changes. In the predicted price changes regression, it lost statistical significance but the standard error estimates are much more variable so one cannot draw too much statistical inference from there. Overall, this exercise suggests that my model has some independent predictive power.[14]

Moreover, the predicted price changes regressions help differentiate my mechanism from a speculative channel. In the presence of speculation, expected duration can also forecast future price changes. Speculators bet on continued price increase by flipping the properties quickly which simultaneously drive up the prices in the short run. However, since speculators are by definition chasing price trends that are unrelated to macro fundamentals, one do not expect duration to be predictive on price changes that are due to macro variations. Results in column (5)-(7) of Table 4 thus suggest the forecasting power of the expected duration is more likely to come from the rational channel as my model suggests.

[14]The regressions with the interactive term also sheds light on an alternative mechanism that could also generate return predictability. Mayer (1995) gives another explanation for a larger discount on auction prices in down markets, that is due to decreased number of bidders and winners pay on average a higher mismatch cost. However, this particular mechanism has a strong impact on return predictability in the less dense market in which the decrease in bidder number is most pronounced. This is contrast to my model's prediction and the result on the interactive term provides evidence in favor of my hypothesis.

I perform more robustness checks. In particular, my model highlights buyers' idiosyncratic consumption benefits, combined with the auction format and heterogeneous holding horizons, as the driving force for ownership duration predictability. That provides the implication that the mechanism should apply better in owner-occupied houses that are significantly different from rental units. Observe in Table. 1 that the majority of the sample consists of single family houses and the average size of the house is 2150 square feet. That suggests this sample is quite suitable for performing empirical tests of my model. In addition, I also run the test using only house units whose size or purchase price is above the 25% percentile of the distribution at the MSA level per purchase year. The particular 25% threshold is chosen for two reasons. First, fewer observations will be left if a larger criteria is used and that will increase noise and decrease the power of the test. Second, from the summary statistics, 25% seems to be a good separating threshold. For example, the 25% of the size distribution in the pooled sample is 1500 square feet. The results are not reported here but are very similar with before, regardless of whether we use size or price to obtain the sub-sample. There is still a strong negative co-movement relationship between price and expected duration measure. In addition, current expected duration has predictive power on the future return component that is forecastable by macro fundamentals.

6 Concluding Remarks

I propose an explanation for the observed positive correlation between price and turnover rate during the boom and bust cycle in the residential housing market that is consistent with rational expectations in a frictionless setting. Agents are forward looking and derive their valuation based on housing service costs and expected capital gains. Trade occurs through second-price sealed-bid auctions. Heterogenous valuations arise from both heterogeneous tastes for housing consumption and from different expected sale price with different holding horizons. In the presence of heterogeneous agents, the equilibrium price characterization under the auction mechanism implies that short horizon buyers tend to have a relatively higher resale option valuation in the good state of the world than in the bad state. As a result, they are more likely to win the asset in good market conditions and long horizon buyers are more likely to outbid and win in less favorable market conditions. The time varying ownership type contributes to the state-dependent turnover rate that co-moves positively with the price dynamics if the macro fundamental is persistent. I test the model's implication using the American Housing Survey. I find empirical evidence consistent with my model's predictions. In particular, the expected durations of home owners are negatively correlated with house prices at the MSA level and the current expected duration has forecasting power on future price changes, especially those that are predictable by current macro conditions.

The model is built to be parsimonious in order to focus on the joint effect of heterogeneous agents as well as their strategic interaction during purchase as implied by the auction mechanism on asset market dynamics. Albeit simple, this exercise with bidding as the price formation mechanism suggests that, in the presence of heterogeneous agents, specific trading formats that feature strategic interaction at the micro level could have a non-trivial impact on aggregate equilibrium prices and trading dynamics. Given the popularity of use of auctions in other asset market, for example the one of corporate asset sales, future research on auction mechanism's implications on asset dynamics in a broader context could be fruitful.

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Appendix

A Proof of Lemma 1

In the presence of private consumption benefits associated with home ownership, consumers will be indifferent between paying the market rent and live in the rental market and owning by paying the rental cost adjusted for the idiosyncratic private value. The indifference reservation price for each type of consumers then consists of a component that equals the rental cost given the consumer's horizon. In addition, since owners are entitled to capital gains/losses associated with asset ownership, their reservation price also incorporates the expected price at time of sale given their different horizons. Given the second-price auction format, by the revelation principle, they will bid the true value of their reservation price. Q.E.D.

B Proof of Proposition 1

With $P^L = p^L Y^L$ and $P^H = p^H Y^H$ and $y = Y^H/Y^L$, we can rewrite the equations for $\overline{U_s}, \underline{U_s}$ and $\overline{U_l}, \underline{U_s}$ in (3.3) and obtain $\overline{U_s^i} = \overline{u_s^i} Y^i, \underline{U_s^i} = \underline{u_s^i} Y^i$ and $\overline{U_l^i} = \overline{u_l^i} Y^i, \underline{U_l^i} = \underline{u_l^i} Y^i$ where $\overline{u_s^i}, \underline{u_s^i}, \overline{u_l^i}$ and $\underline{u_l^i}$ are given by (3.7). With uniform distribution specification, one can show easily that the system (3.5) is linearly homogeneous of degree one in Y, so we can reduce it to one independent of Y^L, Y^H as shown in (3.5) by scaling. Furthermore, in this case, reservation prices for the two types of agents are distributed as uniform$[\underline{u_j^i}, \overline{u_j^i}]$, $i = L, H$ and $j = s, l$. Then the equilibrium state prices $p^i, i = L, H$ are distributed as the minimum of the two reservation value random variables above with support $[min(\underline{u_s^i}, \underline{u_l^i}), min(\overline{u_s^i}, \overline{u_l^i})] \equiv [lower^i, upper^i]$ and its cdf is in general given by,

$$
\begin{aligned}
F_p^i &= Prob\big(min(p_s^i, p_l^i) < p\big) \\
&= F_s^i(p) + F_l^i(p) - F_s^i F_l^i \\
&= \frac{p - \underline{u_s^i}}{\overline{u_s^i} - \underline{u_s^i}} + \frac{p - \underline{u_l^i}}{\overline{u_l^i} - \underline{u_l^i}} - \frac{(p - \underline{u_s^i})(p - \underline{u_l^i})}{(\overline{u_s^i} - \underline{u_s^i})(\overline{u_l^i} - \underline{u_l^i})}
\end{aligned} \tag{B.1}
$$

where p_j^i is random variable for the type j agent's reservation value at state i and F_j^i is the associated cumulative distribution for type j's at state i. We further split the support into two regions, $[lower^i, \max(\underline{u_l^i}, \underline{u_s^i})]$ and $[\max(\underline{u_l^i}, \underline{u_s^i}), upper^i]$. Notice in the first sub-region, the probability of the minimum is smaller than some number is just the probability of the single random variable that has positive mass in this region. The formula for cdf of the minimum in (B.1) only applies in the latter sub-region. As such, we arrive at the equations in (3.6). Q.E.D.

C Proof of Proposition 2

The expected winning probability for one type of agents is just the *ex ante* probability of having a higher reservation value in that state among the two types of agents, taking the equilibrium prices as given. In general, we have $Prob(p_s^i < p_l^j) = E[Prob(p_s^i < x_l^j)|p_l^j = x_l^j]$. Alternatively, we can write $p_s^i = x_s^i + \frac{E^i[P_{t+1}]}{1+r}$ and $p_l^i = x_l^i + \frac{E^i[P_{t+2}]}{(1+r)^2}$. Then the probability of the long bidder wins is also equal to $E[Prob(x_l^i > x - g^i)|x_s^i = x]$, where $x_s^i \sim Uniform(0, u_s^i)$ and $x_l^i \sim Uniform(0, u_l^i)$. Notice that $Prob(x_l^i > x - g^i) = 0$ if $u_s^i - g^i > u_l^i$, so we take the integral to the minimum of u_s^i and $u_l^i + g^i$. Also, for all values that $x_s^i - g^i < 0$, $Prob(x_l^i > x - g^i) = 1$. Thus with probability g^i/u_s^i long bidder wins given all her realizations, when $x_s^i - g^i < 0$. Taken together, we arrive at (3.8).

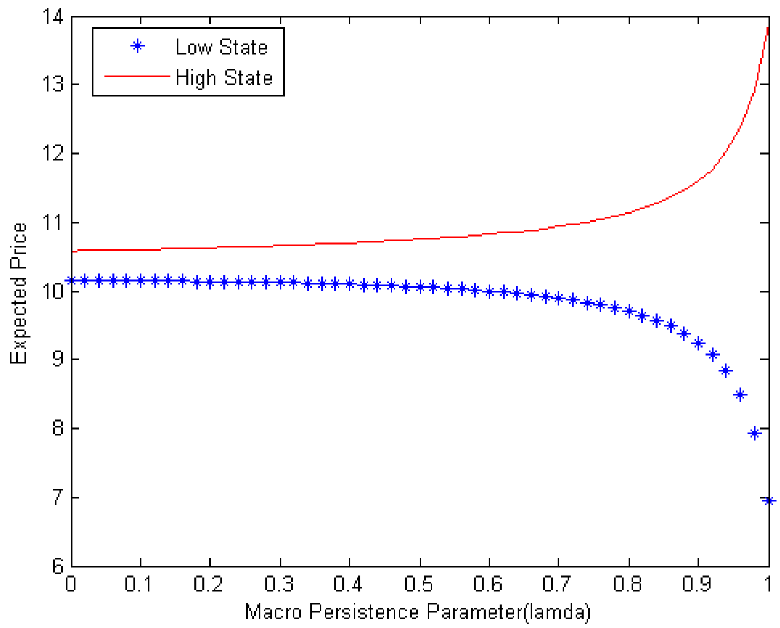
The steady-state turnover rate in the model corresponds to the probability that the owner-occupied housing asset is up for sale. Then Q^L is the unconditional probability of asset for sale in the low macro state, which is the sum of two conditional probabilities that the asset is for sale by a long/short owner in the low state. Denote the two conditional probabilities as Q_s^L and Q_l^L. Similarly, the unconditional probability of asset sale in the high macro state, Q^H, is the sum of conditional probabilities Q_s^H and Q_l^H. Denote $Pr_i^s(\lambda)$ as the probability of agent type i winning the auction in state s conditional on the asset available for sale at that time. As we already see, they depend on the persistence parameter which we will suppress later for notational brevity. By definition, $Pr_s^H + Pr_l^H = 1$ and $Pr_s^L + Pr_l^L = 1$. Then $Q^L, Q_s^L, Q_l^L, Q^H, Q_s^H, Q_l^H$ satisfies the following equations,

$$\begin{aligned}
Q_l^L &= Pr_l^L(\lambda^2 + (1-\lambda)^2)Q^L + Pr_l^H 2\lambda(1-\lambda)Q^H \\
Q_s^L &= Pr_s^L \lambda Q^L + Pr_s^H(1-\lambda)Q^H \\
Q_l^H &= Pr_l^L 2\lambda(1-\lambda)Q^L + Pr_l^H(\lambda^2 + (1-\lambda)^2)Q^H \\
Q_s^H &= Pr_s^L(1-\lambda) + Pr_s^H \lambda Q^H \\
Q_l^L + Q_s^L &= Q^L \\
Q_l^H + Q_s^H &= Q^H \\
Q^L + Q^H &= 1
\end{aligned} \tag{C.1}$$

Note the probability of the asset being put up for sale by a long horizon owner in the low state (Q_l^L) is the probability of him winning two periods before and transition into the low state. If it is a low state then and the asset is for sale, he wins with probability Pr_l^L and transition to the low state with probability $(\lambda^2 + (1-\lambda)^2)$. On the other hand, if an auction occurs in a high state two periods before, he wins with probability Pr_l^H and transition to the current low state with probability $2\lambda(1-\lambda)$. Taking the unconditional expectation of those two possibilities leads to the first equation above. Likewise, the probability of a long horizon seller in a high state Q_l^H is a unconditional expectation of the probability of him winning two periods before and transition to the current high state. For the short horizon owner to sell this period, he has to win one period before. Then $Q_s^L(Q_s^H)$ is the weighted sum of him winning in different states one period before and transition to the current low (high) state.The last three equations are obtained by definition of these six variables. Note although we list seven equations, they are linearly dependent and we still have a unique solution for the six unknown variables as in (3.9). Q.E.D.

Fig. 2: Expected Price and Turnover Rate in the Steady-State Equilibrium

The following are the expected prices and turnover rate as a function of λ in the steady-state equilibrium. In the figure, we use the following parameters: $Y_L = 1$; $Y_H = 2$; r=0.1; $\psi = 1$.



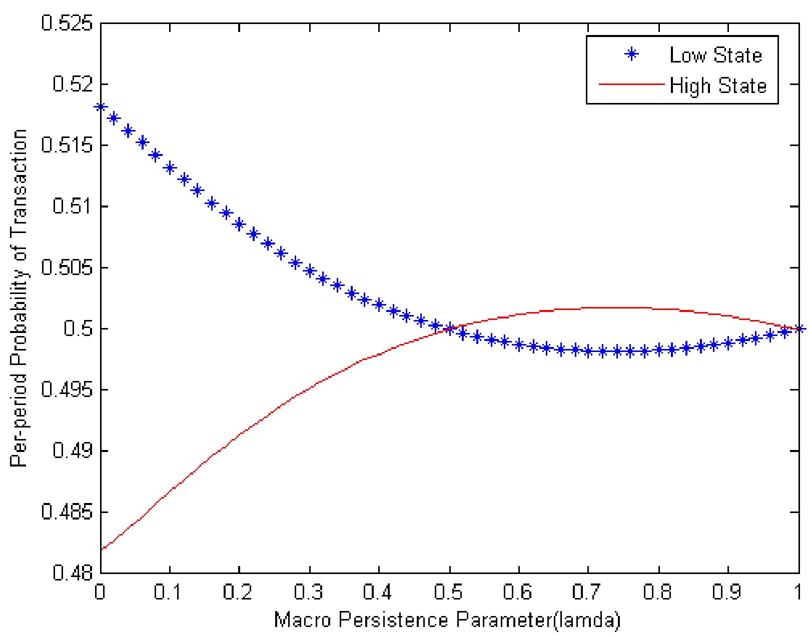


Fig. 3: Short Horizon Type's Equilibrium Expected Conditional Winning Probability

The following is the short horizon agents' expected winning probability as a function of λ, conditional on the owner-occupied asset is available for sale. In the figure, we use the following parameters: $Y_L = 1$; $Y_H = 2$; r=0.1;$\psi = 1$.

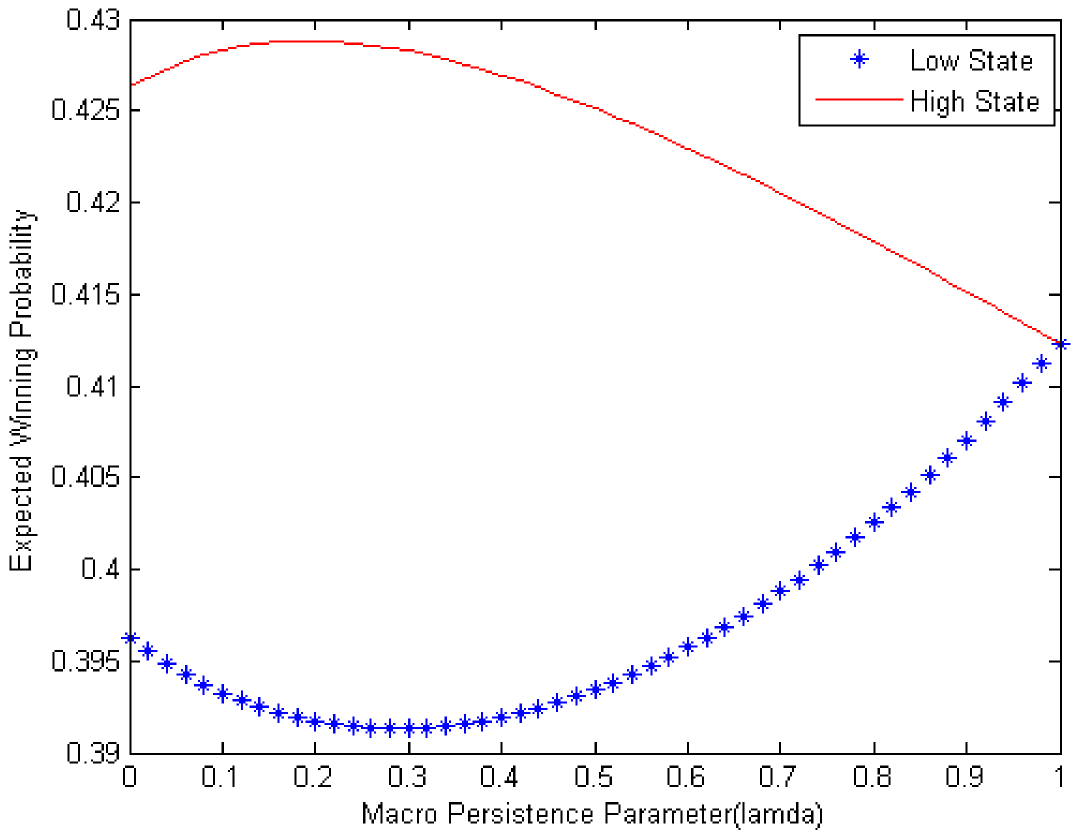


Fig. 4: Average Expected Duration in the US

We plot the expected duration in the US against the observed duration in the top panel and the expected duration in the US against HPI (in 2006 dollars) in the bottom panel.

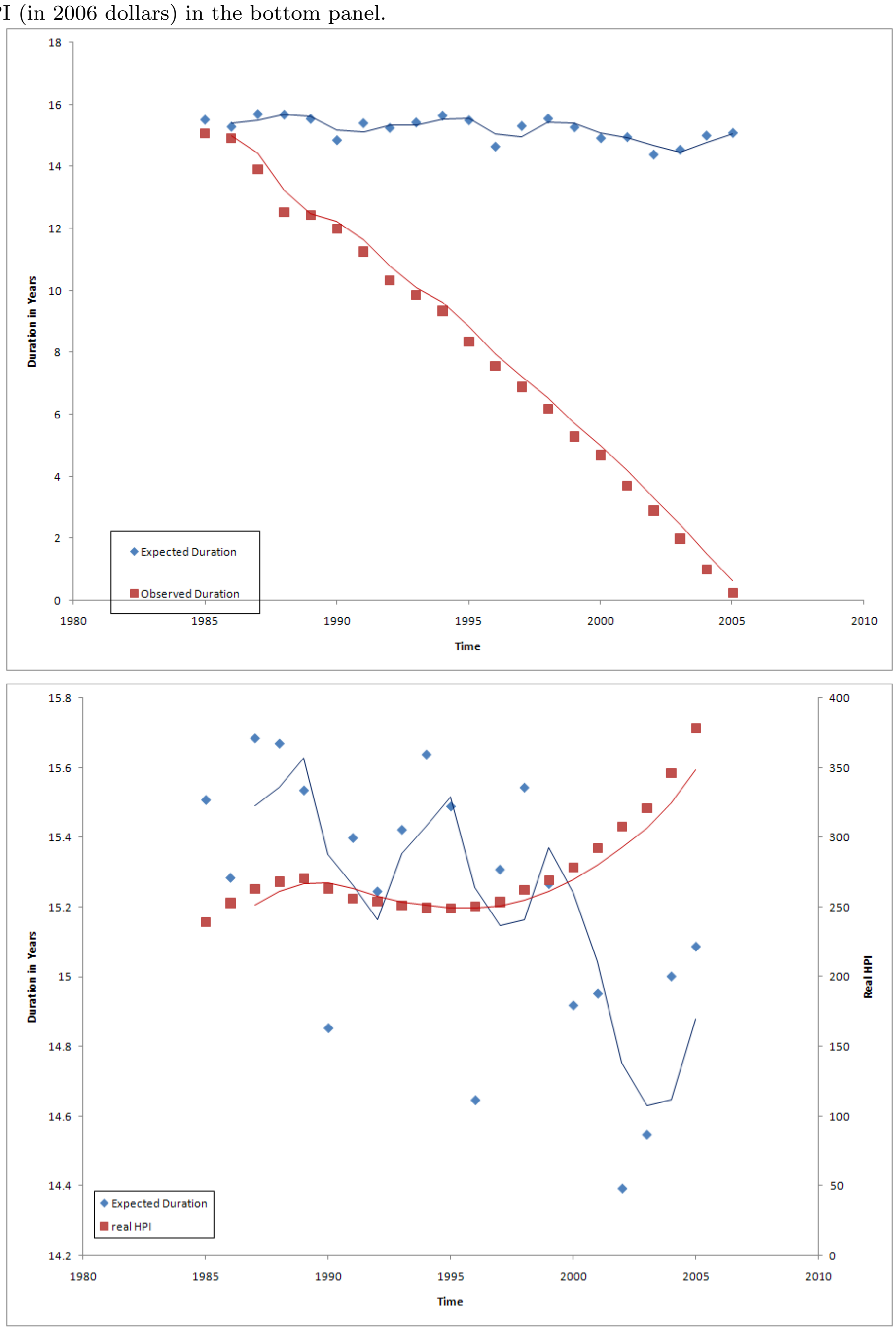


Fig. 5: The Average Expected Duration in US and Northern and Southern California

The California series contain MSA areas with codes 7400,7360,5775,4480,7480,6780 and 360. They represent San Francisco, Oakland, San Jose, LA-Long Beach,Orange County,Santa Barbara-Santa Maria-Lompoc and Riverside-San Bernardino.

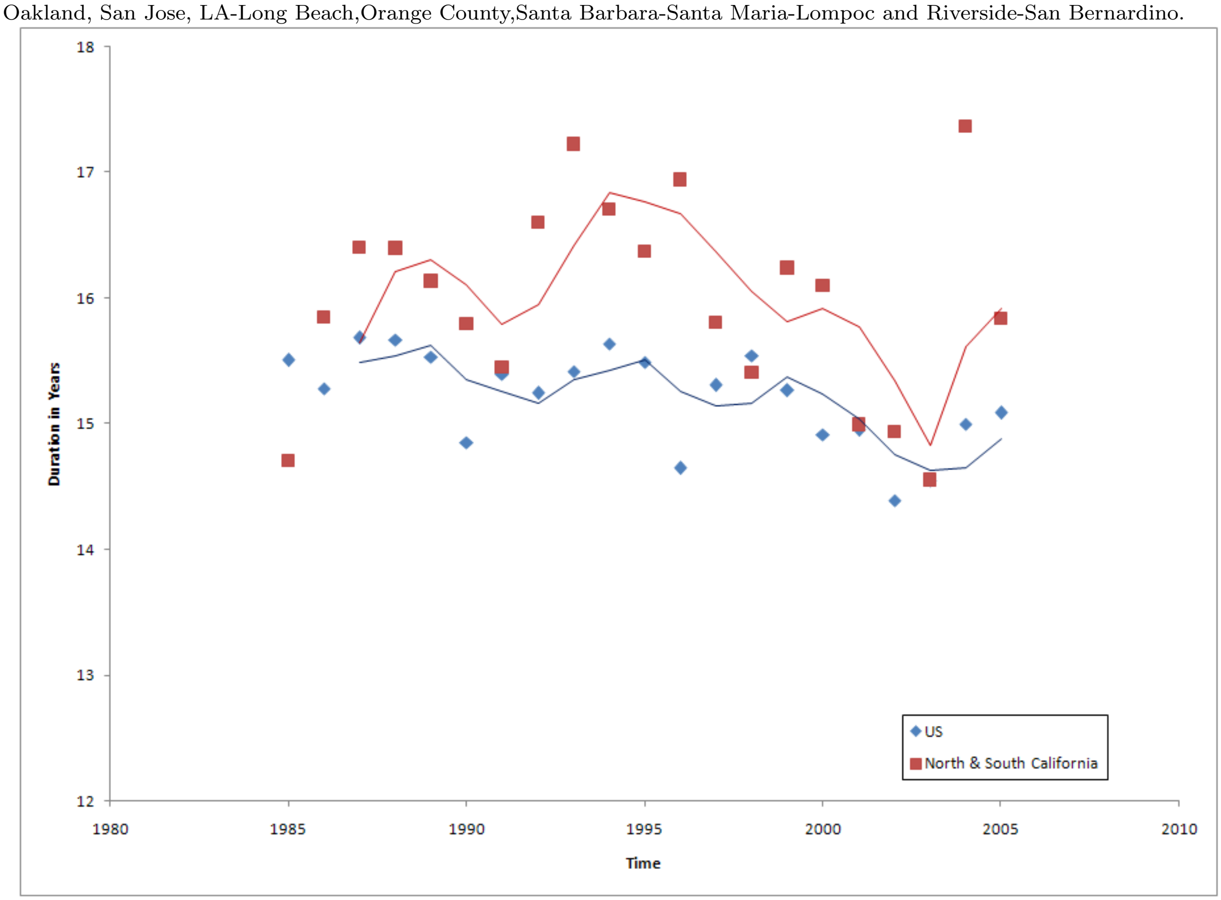


Table 1: Summary Statistics

Some specific data construction issues:
– The pooled sample is taken from the national sample of AHS from 1985 to 2005. We restrict the sample of owner-occupied observations only. In addition, variables reported here reflect the owner or house characteristics at time of purchase. The table presents owners with purchase year ranging from 1970 to 2005.
– We obtain annual income, unemployment as well as other demographic data at the MSA level from CPS and the interest rate data from GFD. – The values of owners' income and house value at time of purchase are in 2006 dollars, deflated by the consumer price index from the Bureau of Labor Statistics.

Variables	Description	Mean	Std Ev	N
age	age	40.94	12.51	12165
mar	marital status	0.74	0.44	12165
sex	gender	0.73	0.44	12165
race	race	1.23	0.79	12165
per	family size	3.16	1.44	12165
highsch	dummy = 1 if owner finished high school	0.28	0.45	12165
somecol	dummy = 1 if owner had attended college	0.26	0.44	12165
college	dummy= 1 if owner finished college	0.42	0.49	12165
realinc	household income (in real terms)	88791.98	68532.39	12155
frstho	dummy = 1 if first time home owner	0.35	0.48	12165
invest	dummy = 1 if purchased it for investment	0.01	0.10	12165
type	type of the housing unit	1.01	0.33	12162
yearbuilt	year the housing unit was built	1965	22.14	12165
unitsf	square feet of the housingunit	2150.25	871.84	11472
rooms	number of rooms in the unit	6.98	1.72	12165
hown	owner's rating of neighborhood quality	8.62	1.58	11998
howh	owner's rating of unit as a place to live	8.80	1.36	12020
realprice	purchase price of unit and land	197439.5	133795.7	11023
dwnpay	means of of downpayment	2.29	1.92	11604
LTV	1st mortgage amount/purchase price (%)	78.15	21.12	9018
trade	year current owner moved in	1991	8.53	12165
duration	duration of ownership	11.55	8.73	12165
cn	dummy = 1 if duration is censored	0.67	0.47	12165
meansmsainc	average income by smsa	57482.57	11057.09	4699
meansmsaunemploy	average unemployment rate by smsa (%)	3.20	0.99	4699
rates	10 year constant maturity treasury rate	1.92	.31	12165
meansmsaownerpct	average ownership rate by smsa(%)	61.90	14.63	4699
collegept	average % of college graduates by smsa	32.02	8.34	4699
oldpt	average % of > 65 year olds by smsa	20.39	5.21	4699
middlept	average % of 40-65 year olds by smsa	41.24	5.03	4699
marriedpt	average % married by smsa	54.93	5.54	4699

Table 2: MLE Estimation of the Expected Duration

1. This table presents the results from MLE estimation of the expected duration from AHS data. The independent variable duration (D) is taken into log terms before the estimation.
2. Standard errors are clustered at the MSA level. Robust standard errors are in parentheses, with * significant at 10%, ** significant at 5% and *** significant at 1% level. Standard errors are clustered at the MSA level.

	ln D		
age	0.006	retire	-0.260
	(0.003)*		(0.080)***
race	0.080	sex	0.008
	(0.017)***		(0.026)
somecol	-0.302	college	-0.420
	(0.033)***		(0.036)***
highsch	-0.196	frstho	-0.086
	(0.042)***		(0.031)**
invest	-0.961	type	0.053
	(0.091)***		(0.007)***
builtage	-0.003	ln(unitsf)	0.070
	(0.001)***		(0.033)***
howh	0.042	hown	0.030
	(0.011)***		(0.010)***
dwnpay	0.016	selection(=1 if purchase< 1985)	1.085
	(0.005)***		(0.028)***
LTV	-0.233	Constant	7.093
	(0.028)***		(1.168)***
Obs.	8415	Pseudo R^2	0.083

Table 3: Correlation between Expected Duration and Macro Variables: MSA Level

1. This table presents the results of OLS regressions taking the specification of Equation (5.2). Expected duration and all macro variables that are in levels are in log terms.
2. The first four columns show the regression that include purchases prior to 1985. In order to control for selection problem, we restrict the observations to purchases after 1985 in the second four columns.
3. MSA fixed effects are included in all three specifications. Since it is possible that within an MSA area there are no observations for one purchase year, we also control for the number of years between purchase observations in the area.
4. Standard errors are clustered at the year level. Robust standard errors are in parentheses, with * significant at 10%, ** significant at 5% and *** significant at 1%.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$\Delta_{t,t-1}\bar{\bar{d}}$	$\Delta_{t,t-1}\bar{\bar{d}}$	$\Delta_{t,t-1}\bar{\bar{d}}$	$\Delta_{t,t-1}\bar{\bar{d}}$	$\Delta_{t,t-1}\bar{\bar{d}}$	$\Delta_{t,t-1}\bar{\bar{d}}$	$\Delta_{t,t-1}\bar{\bar{d}}$	$\Delta_{t,t-1}\bar{\bar{d}}$	$\Delta_{t,t-1}\bar{\bar{d}}$
	[1970,2005]	[1970,2005]	[1970,2005]	[1970,2005]	$\geq$ 1985	$\geq$ 1985	$\geq$ 1985	$\geq$ 1985	$\geq$ 1985
$\Delta_{t,t-1}inc$	-0.037	-0.046			-0.046	-0.084			
	(0.110)	(0.090)			(0.150)	(0.160)			
$\Delta_{t,t-1}unemploy$		0.002				0.001			
		(0.010)				(0.010)			
$\Delta_{t,t-1}rates$		0.228				0.216			
		(0.190)				(0.200)			
$\Delta_{t,t-1}cpi$		-0.464				-1.522			
		(0.280)				(1.010)			
$\Delta_{t,t-1}\overline{p}$			-0.05	-0.04			-0.067	-0.055	-0.041
			(0.019)**	(0.015)**			(0.022)***	(0.019)***	(0.017)**
$\Delta_{t,t-1}owner\%$									0.009
									(0.150)
$\Delta_{t,t-1}middle\%$									-0.031
									(0.170)
$\Delta_{t,t-1}old\%$									-0.001
									(0.210)
$\Delta_{t,t-1}college\%$									0.196
									(0.160)
$\Delta_{t,t-1}married\%$									0.389
									(0.141)**
$\Delta_{t,t-1}invest$	-1.195	-1.198	-1.058	-1.033	-1.173	-1.164	-1.018	-0.992	-1.125
	(0.079)***	(0.079)***	(0.074)***	(0.077)***	(0.079)***	(0.073)***	(0.076)***	(0.078)***	(0.103)***
$size_{t-1}$									0.023
									(0.030)
$\Delta_{t,t-1}size$									0.029
									(0.030)
Time FE	No	No	No	Yes	No	No	No	Yes	Yes
Constant	-0.006	-0.001	0.021	-0.097	-0.005	-0.001	0.041	-0.279	-0.347
	(0.040)	(0.030)	(0.040)	(0.150)	(0.040)	(0.030)	(0.040)	(0.140)*	(0.300)
Obs.	1317	1317	1975	1975	1105	1105	1511	1511	1089
R^2	0.132	0.15	0.156	0.458	0.147	0.169	0.197	0.524	0.485

Table 4: OLS Regression on Price Forecasting: MSA level

1. This table presents the results of OLS regressions taking the specification of Equation (5.3) and (5.4). Expected duration and all macro variables that are in levels are in log terms.
2. In column (3) where we test (5.4), we first project MSA level observed price changes on a vector of macro variables, including MSA level mean income and unemployment rate, interest rates and inflation rates (CPI). MSA fixed effects are also included in this regression. The resulting regression has an adjusted R^2 of 0.54. We have also done a robustness check in the
first stage where we leave out the MSA fixed effects. The result is very similar to what we report here.
3. MSA fixed effects are included in all specifications. Since it is possible that within an MSA area there are no observations for one purchase year, we also control for the number of years between purchase observations in the area.
4. Standard errors are clustered at the year level. Robust standard errors are
in parentheses, with * significant at 10%, ** significant at 5% and *** significant at 1%. 5. As a robustness check, we compute the 95% confidence for standard errors using bootstrapping methods. The results are presented under the OLS standard errors for each variable in square brackets. The number of replications used is 5000.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	$\Delta_{t,t-1}\overline{p}$	$\Delta_{t,t-1}\overline{p}$	$\Delta_{t,t-1}\overline{p}$	$\Delta_{t,t-1}\overline{p}$	$\Delta_{t,t-1}\overline{\tilde{p}}$	$\Delta_{t,t-1}\overline{\tilde{p}}$	$\Delta_{t,t-1}\overline{\tilde{p}}$
	$\geq$ 1985	$\geq$ 1985	$\geq$ 1985	$\geq$ 1985	$\geq$ 1985	$\geq$ 1985	$\geq$ 1985
$\overline{\tilde{\mathbf{d}}_{\mathbf{t-1}}}$	-0.01	-0.002	-0.019	-0.039	-0.053	-0.053	-0.017
	(0.062)	(0.061)	(0.062)	(0.051)	(0.015)***	(0.015)***	(0.006)***
	[0.037,0.087]	[0.035,0.086]	[0.028,0.096]	[0.008,0.093]	[0.009,0.021]	[0.009,0.020]	[0.002,0.010]
$\overline{\tilde{\mathbf{d}}_{\mathbf{t-1}}} \times \mathbf{SF}$		-0.282	-0.279	-0.204		0.002	-0.0003
		(0.113)**	(0.108)**	(0.136)		(0.038)	(0.021)
		[-0.192, 0.418]	[-0.189,0.405]	[-0.173,0.444]		[-0.029,0.104]	[-0.016,0.058]
$\overline{p_{t-1}}$	-0.913	-0.912	-0.879	-0.892	-0.402	-0.402	-0.415
	(0.051)***	(0.051)***	(0.080)***	(0.063)***	(0.012)***	(0.012)***	(0.006)***
	[0.021,0.081]	[0.020,0.081]	[0.035,0.126]	[0.030,0.095]	[0.006,0.017]	[0.006,0.017]	[0.003,0.008]
$ownership\%_{t-1}$				0.17			0.034
				(0.240)			(0.028)
				[0.100,0.379]			[0.012,0.044]
$middle\%_{t-1}$				0.595			0.606
				(0.290)*			(0.035)***
				[0.144,0.437]			[0.014,0.054]
$old\%_{t-1}$				-0.111			0.229
				(0.484)			(0.024)***
				[0.269,0.699]			[0.008, 0.040]
$college\%_{t-1}$				0.693			0.375
				(0.326)**			(0.035)***
				[0.199,0.454]			[0.019,0.051]
$married\%_{t-1}$				-0.551			-0.549
				(0.286)*			(0.030)***
				[0.133,0.439]			[0.013,0.047]
$\Delta_{t-1,t-2}\overline{p}$			-0.023	-0.042			-0.004
			(0.041)	(0.034)			(0.004)
			[0.019,0.063]	[0.018,0.051]			[0.002,0.006]
$\Delta_{t-1,t-2}\overline{\tilde{d}}$			0.067	0.012			0.004
			(0.038)*	(0.037)			(0.004)
			[0.017,0.058]	[0.017,0.056]			[0.001,0.006]
$\Delta_{t,t-1}size$	0.512	0.514	0.523	0.587	0.598	0.598	0.627
	(0.046)***	(0.046)***	(0.045)***	(0.056)***	(0.009)***	(0.009)***	(0.003)***
	[0.029,0.063]	[0.030,0.063]	[0.028,0.062]	[0.038,0.075]	[0.004,0.014]	[0.004,0.014]	[0.002,0.005]
$size_{t-1}$	0.393	0.393	0.418	0.503	0.179	0.179	0.243
	(0.079)***	(0.079)***	(0.076)***	(0.072)***	(0.015)***	(0.015)***	(0.006)***
	[0.043,0.115]	[0.044,0.114]	[0.044,0.108]	[0.043,0.102]	[0.006,0.024]	[0.006,0.024]	[0.003,0.008]
Constant	8.158	8.146	7.611	6.87	3.674	3.674	3.117
	(0.447)***	(0.450)***	(0.758)***	(0.880)***	(0.142)***	(0.143)***	(0.069)***
	[0.232,0.661]	[0.233,0.668]	[0.363,1.154]	[0.422,1.338]	[0.057,0.227]	[0.055,0.231]	[0.032,0.107]
Obs.	1335	1335	1314	1013	1018	1018	1013
R^2	0.61	0.611	0.609	0.636	0.966	0.966	0.989