

Owner-Occupied Housing as a Hedge Against Rent Risk

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ABSTRACT

Conventional wisdom assumes that homeownership is risky because house prices are volatile. But all households start life “short” housing services, and homeownership could be a less risky way of obtaining those services than the alternative, renting. While a renter faces year-to-year fluctuations in rent, a homeowner receives a guaranteed flow of housing services at a known price, and so is hedged against rent risk. Although the homeowner is in turn exposed to asset price risk when she sells her house, that risk can be relatively small since it arrives at the end of the stay in the house and so is discounted, or it is deferred even later if the homeowner moves to a correlated housing market. We show in a stylized model with endogenous house prices that rent risk can indeed outweigh asset price risk. The net benefit of homeownership increases in the owner’s expected horizon in the home, as the number of rent risks avoided rises and the asset price risk occurs later in time. This effect of horizon on the demand for owning should increase multiplicatively with the magnitude of the volatility of rents. Another implication of our analysis is that the aggregate wealth effect from fluctuations in house prices may be small since higher prices are generally offset by equivalent increases in the expected cost of future housing services.

We test these implications using MSA-level data on house prices and rent volatility matched with CPS data on homeownership. Consistent with the model, the difference in the probability of homeownership between households with long and short expected horizons in their residences is 2.9 to 5.4 percentage points greater in high rent variance MSAs than in low rent variance MSAs. The sensitivity to rent risk is greatest for households that exogenously must devote a larger share of their budgets to housing. Similarly, the “younger” elderly who live in high rent variance MSAs are more likely to own their own homes on average, but their probability of homeownership falls faster as they approach the end of life and their horizon shortens. Finally, we find that the house price-to-rent ratio capitalizes not only expected future rents, but also the associated rent risk premia, consistent with asset pricing models. At the MSA level, a one standard deviation increase in rent variance increases the house price-to-rent ratio by 2 to 4 percent.

Keywords: house prices, house price risk, rent risk, housing tenure choice, household risk management, aging and housing wealth

JEL codes: R21, E21, G11, G12, J14

According to the 2000 Decennial Census, 68 percent of U.S. households own the house they live in. Those households commit a substantial portion of their net worth to their house, 27 percent on average [Poterba and Samwick (1997)]. For households with heads aged 65 and over, housing wealth comprises 45 percent of their non-Social Security wealth. Conventional wisdom holds that this substantial, undiversified exposure to real estate assets makes home owning quite risky, since fluctuations in house prices can have a sizeable effect on households' financial net worth.

In this paper we demonstrate that homeownership is less risky than conventionally assumed. The starting point of our analysis is that households are in effect born "short" housing services, since they have to live somewhere. They must make up this housing deficit in some way. The key question is whether it is better to procure their desired housing services by renting or by owning. Renters are subject to annual fluctuations in rent, which is the spot price of housing services. Since housing costs are the largest component of most households' budgets, representing on average about a third of annual income, and market rents can be quite volatile (with an average standard deviation of 2.9 percentage points per year), this rent risk can be substantial.

By contrast, a homeowner locks in the cost of future housing services by paying a known up-front price for a house that delivers a guaranteed stream of housing services. Buying a house is akin to purchasing a security that pays out annual dividends equal to the spot rent. Thus homeownership provides a hedge against fluctuations in the cost of housing services: if rents increase, the security pays just enough more to make up the difference. In practice this hedge is available only by owning. Long-term rent contracts are rare in the U.S.: Genesove (1999) reports

that 97.7 percent of all residential leases are for terms of one year or less. Also, one cannot purchase a “rent swap” to exchange variable rents for fixed rents.¹

In exchange for avoiding rent risk, the homeowner faces asset price risk when he moves (or dies) and sells the house. However, this risk can be low. The key reason that there is any asset price risk at all is that houses “outlive” their owners. That is, the hedges provided by houses last longer than their owners’ need to satisfy their short positions in housing services while avoiding rent risk. If residence spells were infinite (or in a dynastic setting, if descendants live in the same houses as their parents), homeownership would not be risky at all, since there would be no sale price risk. Even with a finite horizon, a household’s effective residence spell is longer than its actual one if it moves within the same or correlated housing markets.

This analysis also implies that the aggregate wealth effect from fluctuations in house prices may be relatively small. For example, in our framework an increase in house prices occurs because the expected present value of spot rents has risen (assuming no change in risk premia or discount rates). This implies that households’ short positions in housing services have become more expensive to fulfill. Hence increases in house prices that raise the net worth of current homeowners would generally be accompanied by a potentially offsetting decline in the effective wealth of renters and future homeowners. Moreover, every housing transaction is just a transfer between a buyer and a seller, and so tends to wash out in the aggregate.

Of course, homeownership does not strictly dominate renting. Households must trade off the rent insurance benefit of owning against its asset price risk. We illustrate this tradeoff with a stylized model of tenure choice in the presence of both rent risk and house price risk. Since house

¹ We can only speculate as to why more rent-insurance contracts do not exist. One possibility is that the necessary contracting is difficult. For example, presumably a swap would have to terminate if one party moved. But if rents fell and the renter owed a sufficient amount of money on his half of the swap, he would simply move and exit the contract. In addition, it may be expensive to put such a swap in place for a long term.

prices endogenously capitalize the discounted value of future rents, the asset price risk increases with rent risk. Which risk dominates on net is largely determined by households' expected length of stay (horizon) in their houses. For households with short horizons, the asset price risk is more likely to dominate, since there are few opportunities for rents to fluctuate and the asset price risk comes early in time. But households with longer horizons experience a greater number of rent fluctuations and the asset price risk comes later in time and so is more heavily discounted. For these households the rent risk can outweigh the asset price risk, and so on net increase the demand for owning. The magnitude of the difference between rent risk and asset price risk increases with the volatility of rents. Hence greater rent volatility increases the rate at which the net rent risk and demand for owning increase with horizon – an implication that we exploit in our empirical analysis.

The model also shows the implications of housing costs being correlated across location and time, by allowing for households to move across locations. Greater cross-sectional correlation in rents (and endogenously, in house prices) across current and future housing markets reduces the effective magnitude of asset price risk because the sale and purchase prices are more likely to offset. Even if the price of the future house is cross-sectionally uncorrelated with the price of the current house, to the degree that house prices are persistent over time, the purchase price of the future house is partially hedged by its own subsequent sale price, which also reduces total asset price risk.

In contrast, the previous literature on housing tenure choice has largely ignored the tradeoff between the rent and asset price risks. Indeed, most studies neglect risk altogether and compute a deterministic user cost of housing.² On the other hand, some recent contributions to the portfolio

² The traditional user cost literature, e.g. Rosen (1979), Hendershott and Slemrod (1983), and Poterba (1984), estimates housing demand as a function of just expected returns on housing. We know of only a few studies that consider rent

choice literature have modeled the demand for owning real estate assets, but they generally consider the associated asset price risk in isolation, neglecting the tenure decision and the riskiness of renting. Instead they focus on various costs of the asset price risk, such as the resulting distortions to homeowners' saving and consumption behavior [Engelhardt (1996), Skinner (1989)], or to their financial portfolio allocations [Brueckner (1997), Flavin and Nakagawa (2003), Flavin and Yamashita (1998), Fratantoni (1997), and Goetzmann (1993)].³ Hence this paper can be seen as extending the existing literatures to account for a central but understudied element of household risk management.⁴ Our framework bears some similarities to term-structure models of long versus short duration bonds, in which holding a long bond provides insurance against fluctuations in short interest rates.

Depending on the elasticity of supply of owned housing units, the insurance demand for home owning may show up in a higher homeownership rate, higher house prices, or both. In an elastically supplied market, the additional demand for ownership that is due to net rent risk will be reflected in a greater probability of home owning. In an inelastic market, house prices will be bid up by the marginal homebuyer until they capitalize not only the discounted value of expected

risk. In a time series study, Rosen *et al.* (1984) finds that one predictor of the aggregate homeownership rate is the difference between the unforecastable volatility of the user cost of homeownership and rents. They assume that rental housing and owner-occupied housing are independent goods, so they do not allow for an endogenous relation between house prices and rent. In Henderson and Ioannides (1983), the rent risk is to the landlord, not the tenant. In their model, the tenant may not properly care for the property. This incentive compatibility problem raises the average rent for renters but does not involve rent volatility. Ben-Shahar (1998) reverses the usual models by including uncertainty about rents but exogenous and riskless house prices. Thus there is no trade-off between rent and price risk in his model. In work subsequent to this paper, Ortalo-Magné and Rady (2002) develop an extended version of our framework that examines the implications of the covariance between rents and earnings.

³ Skinner (1989) and Summers (1983) consider the asset price risk of the house, but not the value of housing as insurance against rent fluctuations. Davidoff (2003) measures asset price risk by how much house prices covary with labor income, and is primarily concerned with the effect of asset price risk on the amount of housing purchased in a portfolio context. He assumes exogenous house prices and does not consider the tradeoff with rent risk.

⁴ Other papers investigate alternative sources of household risk. Cocco (2000) and Haurin (1991) investigate the effects of income risk on housing portfolio choice. Cocco also includes interest rate risk, in a parameterized structural model of housing investment, but he rules out the possibility of renting. Campbell and Cocco (2003) use the covariance of income, interest rates, and house prices to explain whether people finance their house with fixed or floating rate debt. However, their financing decision does not involve the tradeoff between rent expenditures and asset price risk. Other work emphasizes the negative effects of depressed house prices and housing equity on household mobility [Chan (2001), Genesove and Mayer (1997), Stein (1995)].

future rents, but also the risk premia associated with the net rent risk. In such a market, the price-to-rent ratio should rise with rent volatility. We test these implications empirically, using data on both homeownership rates and house prices. Overall we find that the tradeoff between rent risk and house price risk affects households' behavior in ways consistent with our model.

When we use household-level data on homeownership, our empirical strategy exploits the implication that the effect of expected horizon on the demand for homeownership should increase with rent volatility. To isolate the effect of net rent risk from other reasons why households might own their houses, we control for both Metropolitan Statistical Area (MSA) and individual heterogeneity, and compare the difference in the probability of homeownership for exogenously long- and short-horizon households, to see if this difference increases with rent volatility.⁵ In particular, we separately control for the rent variance in households' MSAs and for their expected horizons, and then focus on the *interaction* of the rent variance with the horizon. The interaction term nets out the effect of unobserved factors like moving costs that might contaminate the direct relationship between homeownership and expected horizon.

Using household-level data from the Current Population Survey (CPS) matched to MSA-level rent data, we find that the estimated effect of rent risk on the probability of homeownership is small for households with average expected horizons, but substantially increases for households with longer horizons, consistent with our model. The difference between the likelihood of homeownership for a household with above-the-median expected horizon and that of a below-the-median household is up to 5.4 percentage points greater in high rent variance MSAs than in low rent variance MSAs. We also find evidence that the sensitivity to rent risk is greater for households that face a bigger housing gamble, and so might be effectively more risk averse, because typical

⁵ For example, homeownership can vary with income, demographics and tax benefits [Rosen (1979)], inflation [Summers (1981)], and the agency costs of renting [Henderson and Ioannides (1983)].

rents in their MSA comprise a relatively large portion of their annual income. Among such households, those with long expected horizons are the most responsive to net rent risk, having a 6.1 percentage point higher probability of homeownership relative to other households if they live in a MSA with high rent variance.

The rent insurance benefit of owning is particularly large for the elderly. The “younger” elderly in markets with high rent volatility are more likely to own their homes, consistent with their being generally more risk averse than the marginal homebuyer. All else equal, a household with a head who is 60 years old is 10.1 percentage points more likely to own its home if it lives in a market in the top quartile of rent variance (a level effect). But after age 65 or so, the probability of homeownership begins to decline with age, and more steeply in high rent variance markets. This slope effect is also consistent with our model, because as the end of life approaches, the rent insurance becomes less valuable as the number of periods for which a homeowner expects to be insured against rent risk falls, and the asset price risk is closer at hand. Thus the rent insurance benefit of homeownership may provide a partial explanation for the failure of the elderly to transit out of homeownership at as early an age as traditional life-cycle models predict [Venti and Wise (2000); Megbolugbe, *et al* (1997)].

Unless the supply of owned housing is perfectly elastic, the extra demand for home owning due to rent risk also should be capitalized into house prices. We measure the additional value to owning rather than renting by comparing house prices relative to rents. The price-to-rent ratio for houses is analogous to the price-earnings ratio for stocks. Using MSA-level data, we find that house prices do indeed incorporate a premium for avoiding net rent risk. We also find that the price-to-rent ratio increases with expected future rents, just as a price-earnings ratio should increase with expected future earnings. These results are consistent with our model and other asset-pricing

models of financial assets. At the MSA level, a one standard deviation increase in rent variance raises the average price-to-rent ratio in a market from 15.7 to as much as 16.3. Holding rents constant, this corresponds to a 2 to 4 percent increase in house prices.

The remainder of this paper proceeds as follows. In section I, we present a stylized model of tenure choice in the presence of both rent risk and house price risk. Section II describes our data sources and variable construction. The empirical methodology and results are reported in section III. Section IV briefly concludes.

I. A simple model of the insurance benefit of owner-occupied housing

This section presents a simple model of tenure choice in which the cost of securing housing services is uncertain and house prices are endogenous. The model is stylized in order to highlight certain key tradeoffs between the risks of renting versus those of home owning, so we make a number of simplifying assumptions. Consider a representative, risk-averse household that lives for N years, labeled 0 through $N-1$, after which it dies. To begin with, suppose the household lives in only one residence, making a single tenure decision at birth in year 0. (We will later consider the additional effects if households can move after some time to another location, with housing costs possibly correlated across locations.) For convenience rental units and owner-occupied houses provide the same flow of housing services.⁶ The household chooses at birth its desired quantity of housing services, normalized to be one unit, which it cannot change during its lifetime. Assuming

⁶ Equivalently, the household can be thought of as choosing between owning and renting the same house. The comparative statics below can be generalized to allow the services from the owner-occupied house to exceed those from renting, perhaps due to agency problems. In practice rent risk might also reduce the desired size of rental space (the intensive margin). While this effect is consistent with the insurance motives under investigation, here it would make it more difficult to find an effect on the rent versus own (extensive) margin that we analyze empirically. Hence our results will provide a lower bound for the full importance of the rent insurance motive.

perfect capital markets and known, exogenous lifetime wealth, the household's tenure choice will maximize the expected utility of its wealth net of its housing costs.^{7,8}

The household will accordingly compare the risk-adjusted costs of renting versus owning. Renting is akin to paying for housing services on a spot market. Spot rents fluctuate year to year due to exogenous shocks to the underlying local economy and housing market.⁹ Suppose these rents can be described as following a general AR(1) process: $r_t = \mu + \phi r_{t-1} + \eta_t$, where $\phi \in [0,1]$ measures the degree of persistence in rents, μ measures the expected level or growth rate of rents (depending on ϕ), and the shocks η to rents are distributed $\text{IID}(0, \sigma^2)$.¹⁰

Because there are no capital market imperfections, *ex post* households care only about their total housing costs. Initially, when choosing whether to rent or own, they project forward to the ends of their lives and forecast how much they will have spent *ex post* on housing under each

⁷ Relaxing these assumptions would be complex and not add to our basic insights concerning rent and price risk. Davidoff (2003) finds that the correlation of rents with income could further affect the relative riskiness of renting. In preliminary analysis, we controlled for this type of correlation in our empirical work and found that it does not affect our primary results. The model in Ortalo-Magne and Rady (2002) allows heterogeneous households to make intermediate changes in tenure.

⁸ If the household has a bequest motive, fluctuations in its housing costs lead to uncertainty in the value of its bequest. Hence the household will still want to consider asset price risk when minimizing the risk-adjusted costs of fulfilling its desire for housing services. The two-location extension below applies if the children use the bequest to buy their own house. A partial bequest motive, where the parents do not value their children's utility as highly as their own, would lead to a partial reduction in the cost to the parent of the terminal asset price risk.

⁹ Changes in the spot rent are generated by variation in the demand for housing services. Any number of local economic conditions fluctuate over time and across space, from the success of locally concentrated industries that raises workers' wages to increased immigration or in-migration leading to a larger population. Of course, changes in demand do not necessarily get capitalized into rents. If housing is perfectly elastically supplied, rents are set by construction costs, and greater demand would lead to more housing units, not higher prices. If housing is at least partially inelastically supplied -- perhaps due to zoning, a limited supply of land, time lags in construction, or (when demand falls) an existing durable housing stock (see Glaeser and Gyourko, (2004)) -- then some portion of the changes in demand would show up in rents. As supply becomes more inelastic, underlying demand volatility will have an increasingly large effect on the volatility of rents. In an earlier version of this paper, we found that rent volatility is a function of underlying volatility in the unemployment rate interacted with the inelasticity of supply of housing in the local market (proxied by regulatory constraints on building). These results used cross-MSA variation, however, which is only suggestive, given potential MSA-level heterogeneity.

¹⁰ We take the spot rent process as given, without modeling its underlying determinants. Whatever the ultimate determinants, the model correctly specifies the endogenous relationship that results between rents and house prices. This approach is analogous to other asset-pricing models. For instance, in term structure models of long versus short maturity bonds, the process for short rates (analogous to our rental rates) is the exogenous input into the model. In models of stock prices, the input is the process for firm cash flows, and the stochastic price of a stock at sale is analogous to our house sale price.

tenure option; and they evaluate the corresponding *ex ante* expected utilities. For renters, the *ex*

post total cost of renting, discounted to the final year $N-1$, is $(r_0 R^{N-1} + \sum_{t=1}^{N-1} \tilde{r}_t R^{(N-1)-t}) \equiv C_R R^{N-1}$,

where R is the gross interest rate, for simplicity a constant, and C_R is the total cost of renting, discounted back to year 0. The initial rent r_0 is observed at the time of the tenure decision at time 0, but the future rents are unknown. (The tildes identify stochastic variables as of time 0.) It will be convenient below to discount all values back to the initial year 0 using the discount factor $\delta \equiv 1/R$. Then the (*ex post*) utility of being a renter, U_R , can be simply expressed as a function of the present value of lifetime wealth W less the present discounted cost C_R of the rents that are paid:

$$U_R = U(W - C_R) = U\left(W - r_0 - \sum_{t=1}^{N-1} \delta^t \tilde{r}_t\right).$$

The household can avoid the uncertainty of the future rents by buying its residence in year 0. The house is like a security that pays out in perpetuity annual dividends equal to the spot rent, thus providing a hedge against rent risk. However, while the initial purchase price P_0 is observed (and will be determined in equilibrium below), the sale price P_N is stochastic. Since house prices will endogenously capitalize future rents, the sale price will fluctuate with the rent shocks. This exposes the homeowner to asset price risk at the end of life when he sells the house.¹¹ Hence the (*ex post*) cost of owning, again discounted back to year 0, is $Co \equiv P_0 - \delta^N \tilde{P}_N$, the difference between the purchase price of the house and the discounted proceeds from the subsequent sale of

¹¹ We assume a stationary economy with a sequence of representative households owning and renting a fixed supply of housing and rental units. For consistency, the sale to the next generation is assumed to take place at the beginning of year N , with P_N determined when r_N is observed, etc.

the house.¹² The utility of being an owner, U_o , is just a function of lifetime wealth less the discounted cost C_o : $U_o = U(W - C_o) = U(W - P_0 + \beta^N \tilde{P}_N)$.

We assume that in equilibrium house prices are endogenously determined such that households are *ex ante* indifferent between owning and renting, with $E_0 U_o = E_0 U_r$, so that both owned and rented housing units are occupied. In our model, which implicitly assumes a fixed supply of housing, the equilibrium house price P_0 can be used to measure the demand for owning relative to renting. Of course, the extent to which demand is empirically capitalized into house prices depends on the elasticity of supply. We will return to this distinction later.

Under the above assumptions one can show that the equilibrium house price takes the following form:

$$P_0 = PV(r_0, \mu) + \frac{\pi_r(\sigma^2, N) - \pi_o(\sigma^2, N)}{1 - \delta^N} \quad (1)$$

The house price is the sum of two terms: the present value of expected rents, PV , plus the net risk premium, which consists of the difference between the risk premium associated with renting, π_r , and the risk premium associated with owning, π_o .¹³ We discuss each of these components in turn.

¹² For simplicity we abstract from other factors that affect homeownership and rental costs, such as the tax treatment of homeownership, maintenance, and depreciation. Such factors may affect the relative cost of owning and renting, but they will not qualitatively change the comparative statics at issue here regarding the effects of increases in rent volatility. For example, since interest rates are nearly equal across the country and depreciation schedules are set at the federal level, variation in them over time will not affect our cross-sectional results. Property taxes are incorporated in rents and thus do not differ between owners and renters. Owners have a great degree of flexibility over the timing of maintenance costs, which mitigates their short-run risk; and their long-run maintenance expenditure should be relatively predictable [Gyourko and Tracy (2004)]. Landlords pass along maintenance costs for renters, and thus the maintenance risk is properly measured in our estimate of rent variance. Berkovec and Fullerton (1992) argue that taxes provide some risk sharing between homeowners and the government. We will control for tax regime changes over time in the empirical work.

¹³ In short, to solve the model we equate the certainty-equivalent utilities of renting and owning, $U_r(W - E_0 C_r(r_0, \mu) - \pi_r(\eta_1, \eta_2, \dots, \eta_{N-1})) = U_o(W - E_0 C_o(P_0, r_0, \mu) - \pi_o(\eta_1, \eta_2, \dots, \eta_N))$, after recursively expressing each rent r_t as a function of r_0 , μ , and the shocks η_1 to η_t that arise after year 0: $r_t = \phi^t r_0 + \mu \sum_{i=1}^t \phi^{t-i} + \sum_{i=1}^t \phi^{t-i} \eta_i$. As explained below, the price P_N can be expressed as a function of r_N and so recursively also as a function of r_0, μ , and η_1 to η_N . From this equation we solve for the house price $P_0 = P_0(r_0, \mu, \pi_r - \pi_o)$.

The PV term reflects the observation that the value of a house reflects the value of the housing services that it provides, which is akin to paying out the spot rents:

$$PV(r_0, \mu) = \frac{1}{1 - \delta\varphi} \left(r_0 + \mu \frac{\delta}{(1 - \delta)} \right) \quad (2)$$

The value of these payments is greater than the current rent r_0 ; the second term in the parentheses captures the expected present value of the future rents, which depend on μ , in perpetuity.¹⁴ Just as a price-earnings ratio increases with expected future earnings, the difference between the house price and the current rent will increase with expected future rents. The factor $(1/[1-\delta\varphi]) > 1$ reflects the persistence of rents: with $\varphi > 0$, each increase in rent continues to augment the rents in subsequent periods.

π_R measures the risk associated with renting. It is the risk premium that would leave the household indifferent between paying the discounted cost of renting $C_R (= r_0 + \sum_{t=1}^{N-1} \delta^t \tilde{r}_t)$, which is stochastic, versus paying its expected value $E_0 C_R$ and the premium. This premium can be approximated as:

$$\pi_R(\sigma^2, N) = \frac{\alpha}{2} \sigma^2 \sum_{n=1}^{N-1} \left(\delta^n + \sum_{i=n+1}^{N-1} \delta^i \varphi^{i-n} \right)^2, \quad (3)$$

where α measures household risk-aversion. To interpret this result, note that the outer summation corresponds to the $N-1$ rent shocks η_1 to η_{N-1} that are avoided by owning, with the later shocks discounted more heavily (using δ^n). The inner summation reflects the fact that if $\varphi > 0$, each shock continues to affect rents in subsequent periods, in proportion to its persistence φ . For instance, if the rent shocks are IID, with $\varphi=0$, then the inner summation disappears and π_R is simply equal to

¹⁴ This is true even when the households' horizon N is finite, since when each household sells the house, the sale price will in turn reflect the value of the subsequent rents, appropriately discounted.

$(\alpha/2)*\sigma^2 \sum_{n=1}^{N-1} (\delta^n)^2 = (\alpha/2)*\sigma^2 [\delta^2 + \delta^4 + \dots + \delta^{(N-1)^2}]$. Note that π_R increases with both N , the number of rent shocks the renter faces, and with σ^2 , the magnitude of the rent shocks. Because owning provides the benefit of avoiding the rent shocks, their corresponding risk premia get bid into house prices, so π_R enters equation (1) with a positive sign. This has the important implication that rent risk tends to increase the demand for home owning, *ceteris paribus*.

The risk premium π_o measures the risk associated with the discounted cost of owning Co ($= P_0 - \delta^N \tilde{P}_N$), due to the stochastic sale price P_N :

$$\pi_o(\sigma^2, N) = \frac{\alpha}{2} \sigma^2 \left(\frac{\delta^N}{1 - \delta\varphi} \right)^2 \left(1 + \sum_{i=1}^{N-1} \varphi^{2i} \right) \quad (4)$$

Equations (1) and (2) imply that house prices can be expressed as a linear function of contemporaneous rents, and so house prices endogenously inherit the riskiness of the rent process. Hence the sale price P_N will vary with the contemporaneous rent shock η_N and, if rents are persistent, with the previous shocks η_1 to η_{N-1} as well. The summation term in equation (4) reflects the effect of these previous shocks when $\varphi > 0$. Further, as the volatility of rents σ^2 increases, the sale price P_N becomes increasingly risky. For instance, if rents are IID with $\varphi = 0$, then the summation term disappears because the previous shocks do not affect P_N , and so π_o is simply equal to $(\alpha/2)*\sigma^2(\delta^N)^2$. In this case the sale price risk is of the same magnitude as the individual rent risks, but discounted using δ^N since the sale price is realized N years after purchase. However, as the rent shocks become more persistent as φ increases, the sale price risk increases. More of the prior rent shocks accumulate and are embedded into the sale price, increasing the magnitude of the summation term. For instance, if rent shocks are fully persistent, with $\varphi = 1$, then π_o equals $(\alpha/2)*N\sigma^2[\delta^N/(1-\delta)]^2$. (This is greater than $(\alpha/2)*\sigma^2(\delta^N)^2$ under $\varphi = 0$, since all N rent shocks η_1 to

η_N get fully reflected in the sale price.) π_o enters equation (1) with a negative sign, so unlike rent risk the asset price risk reduces the demand for owner-occupied housing, *ceteris paribus*.

Returning to equation (1), note that if the spot rents are riskless ($\sigma^2=0$) or if households are risk neutral ($\alpha=0$), then the house price P_0 reflects only the expected rental costs in the PV term, as in Poterba (1984). Otherwise, the house price also reflects the *net* risk premium associated with renting relative to owning, $\pi_R - \pi_O$. Since both owning and renting are risky, the tenure decision must consider the tradeoff between the two risky options, rather than either option in isolation. If the sign of the net risk premium is positive, renting is riskier on balance than owning, and so the house price P_0 would be greater than the PV term. That is, risk averse households would bid up the house price because of the hedging benefit that the house provides against rent risk. Moreover, since the net risk premium is proportional to the volatility of rents σ^2 , the house price would then increase with σ^2 , *ceteris paribus*. On the other hand, if the sign of the net risk premium is negative, owning is riskier on balance than renting, and then the house price would decrease with σ^2 .

For example, in the IID case ($\varphi=0$) equation (1) implies that the price-to-rent differential, which is a convenient way to normalize prices, can be written as follows:

$$P_0 - r_0 = \mu \frac{\delta}{1-\delta} + \frac{\alpha}{2} \sigma^2 \left[\sum_{n=1}^{N-1} \delta^{2n} - \delta^{2N} \right] \left(\frac{1}{1-\delta^N} \right) \quad (5)$$

In the square brackets the net risk premium includes $N-1$ positive premia for the rent shocks η_1 to η_{N-1} that are avoided by owning the house, minus one premium for the sale price risk due to P_N , all appropriately discounted. Thus the net risk premium depends on N , the household's expected horizon in the residence. As N increases, the renter faces more rent shocks, which increases the

rent risk-premium π_R ; whereas the sale price risk comes later in time, and is thus discounted more heavily, which reduces the risk premium for owning π_O .

In this IID case, because the house price risk is of the same magnitude as the individual rent risks but discounted more heavily, the rent risks dominate and the net risk premium is necessarily positive for any N . In this case the price-rent differential would unambiguously increase with σ^2 . In contrast, as rent shocks become more persistent (with $\phi > 0$), the sale price risk increases in magnitude. Even though π_R also increases with ϕ , π_O can increase by even more, so it is possible that the sale price risk outweighs the rent risks for small N , making the net risk premium negative. For large N the net risk-premium tends to be positive, with renting being riskier than owning. For intermediate levels of N , the net risk premium can be small and of either sign. Hence, the *average* effect of rent risk σ^2 on house prices is theoretically ambiguous in sign, depending on the horizon of the marginal household, and possibly small in magnitude.¹⁵ Nevertheless, whichever risk dominates on average, the net rent risk increases with N .

Another factor affects house prices in equilibrium. In equation (1) the term $(1/[1-\delta^N]) > 1$ multiplying the net risk premium reflects the fact that the sale price P_N will also incorporate the net risk premium (to leave *future* owners indifferent between owning and renting) and, to compensate, this premium is recursively embedded into the initial purchase price P_0 . For instance, if the net risk premium is positive, thus raising P_N , in equilibrium P_0 must also be increased sufficiently to keep the *initial* owner indifferent between renting and owning, taking into account that he will later sell at P_N and recoup the net risk premium, albeit at a discount. Note that the factor $1/[1-\delta^N]$ declines

¹⁵ Case and Shiller (1989) find that changes in house prices exhibit some persistence. That can be explained in our framework if rents are not random walks. In our annual, MSA-level rent data ϕ is about 0.6-0.7. In this case, using a discount factor of $\delta = 0.94$, the net risk premium in this stylized model is positive so long as the horizon N is greater than 3 to 4 years.

with N : the later the premium in the sale price P_N is recouped, the less valuable it is, and so the smaller need be the compensating effect on P_0 .¹⁶

This effect complicates the overall impact of the horizon N on the house price, which works through the term $(\pi_R - \pi_O)/(1-\delta^N)$ in equation (1). As N increases, the net risk premium in the numerator of this term increases, but the denominator also increases. For $\phi=1$ the entire term is monotonically increasing in N , but for $\phi<1$ it can be non-monotonic in N . For empirically reasonable values of around $\phi=0.7$ and $\delta=0.94$, the term rises steeply with N for $N=2-20$ years, then slightly declines and plateaus. That is, for horizons of up to 20 years, the accumulating rent risks tend to dominate the effect of $1/(1-\delta^N)$, causing the demand for homeownership to increase with N .

The horizon N in equation (1) interacts multiplicatively with the volatility of rents σ^2 . As noted above, as rent volatility increases, the riskiness of renting and owning both increase. The sign of the net effect depends on the household's horizon, and the magnitude of the net effect also depends on σ^2 , which amplifies the difference between the two tenure options. That is, in a city with low rent volatility, a household that prefers owning because it has a long expected horizon in its house prefers it by less than an otherwise identical household living in a high rent volatility city. We highlight this interaction effect because, in providing empirical support for the model, we will focus on the interaction of rent volatility with horizon, $N\sigma^2$. This will allow us to isolate the effects of rent risk from other factors that might also generate a relationship between the demand for homeownership and either N or σ^2 separately.

The degree of risk-aversion α also enters equation (1) multiplicatively. As α increases, the effects of rent volatility and horizon grow in magnitude. Households that are more risk-averse, or

¹⁶ Analogously, fixed moving/transactions costs would reduce P_0 , ceteris paribus, according to the present value of the costs, again to compensate homeowners.

equivalently households that take on larger effective housing gambles, should be more sensitive to rent risk given their horizons.

This analysis suggests that the aggregate wealth effect from house price fluctuations is likely to be relatively small. Equation (1) implies that, absent changes in risk premia or discount rates, increases in house prices reflect a commensurate increase in the present value of expected future rents, which increases the cost of fulfilling households' short position in housing services. For homeowners with infinite horizons, this increase in effective liabilities would exactly offset the increase in the house value (their long position), leaving their effective expected net worth unchanged. Even for homeowners with finite horizons, every housing transaction is just a transfer between a buyer and a seller. That is, a higher house price may raise the net worth of a current owner, but the household who will purchase that house faces an offsetting reduction in net worth. If the propensity to consume out of wealth is similar on average across buyers and sellers, then any resulting wealth effects from house price fluctuations would tend to wash out. For this reason, absent liquidity and collateral constraints, one would expect to find relatively small effects of changes in housing wealth on aggregate consumption.¹⁷ This might help explain why studies of the propensity to consume out of housing wealth find smaller effects at the aggregate level than at the micro level.¹⁸

At the household level, the model shows why homeownership is not as risky as often assumed. In fact, if houses did not outlast their owners, owning would be completely riskless. If

¹⁷ Indeed, bringing renters back into the picture can potentially reverse the usual logic regarding wealth effects. Consider an increase in house prices that is due to an increase in expected future rents. Renters (either current renters or future renters depending on the timing of the rent increases) would experience a negative wealth effect due to the increased housing costs. So it is possible for aggregate consumption to *decline* at the same time that house prices rise, especially if the asset-price effect on the buying and selling households is approximately a wash. In concurrent research, Bajari, Benkard, and Krainer (2003) find small aggregate welfare consequences of a change in house prices, even if households adjust their consumption in response. However, if otherwise constrained households are able to borrow against their housing equity, then increases in house prices can increase aggregate consumption.

¹⁸ See Case, Quigley and Shiller (2003) and Skinner (1996).

their residence spells were infinite, households would purchase a house for the known market price P_0 and never sell. Even with finite horizons, in a dynastic setting in which households pass on the house for their descendants to live in, the effective horizon in the house would again be infinite.¹⁹ In these cases, since utility is determined by the housing service flow rather than by the house price, unrealized house price fluctuations impose no cost on the household.²⁰ The house would provide a perfect hedge against rent risk. This hedge would come at the cost of a larger *ex ante* price (equation (1) with $N=\infty$).

In contrast, with finite horizons houses must be sold at the end of life, which leads to asset price risk *ex post*. In that case the value of avoiding the rent risk net of the asset price risk is appropriately capitalized into the initial purchase price of the house so as to make the representative household indifferent *ex ante* between owning and renting. Of course, households' residence spells are often shorter than their remaining lifetimes because households move. In the next subsection, we show that this asset price risk from moving can be small.

Multiple Locations and Residence Spells

To show the implications of housing costs being correlated across locations and over time, we extend the model to accommodate moving and multiple residence spells in different locations. Unlike at the end-of-life in the one-location model, when a household moves it purchases another

¹⁹ Even if a household sells its house at death, if it bequeaths the proceeds to its descendants and they use the inheritance to buy another house in the same or correlated market, the effective horizon is again longer. Conversely, if a household does not care about the sale price of its house, perhaps because it does not have time to consume against this value before its death, the house price risk can be irrelevant even with a finite horizon.

²⁰ This analysis neglects the role of housing as collateral. If the house were a mechanism for borrowing, declines in house prices could potentially reduce a household's welfare even if its horizon is infinite. In that case, the household would trade off rent risk net of the collateral-induced asset price risk against the sale price risk, so the same trade-off arguments apply. For a general discussion of liquidity constraints, see Zeldes (1989), Jappelli (1990), and Jappelli *et al.* (1998).

house, which introduces additional asset price risk but also corresponding cross-sectional and inter-temporal hedges, which work to offset this risk.

To extend the original, one-location model to incorporate these factors in the simplest possible way, consider just two locations, labeled A and B. Households live in A for N years and then move to B and live there for N more years, after which they die. Location B can be interpreted as the rest of the country, an amalgamation of the many locations to which a household could possibly move. To simplify, we assume that households decide at birth in year 0 either to be homeowners, owning in A and then B, or to be renters, in A and then B, and they do not adjust the quantity of housing services when they move.²¹ Suppose that the spot rent processes in the two locations follow correlated AR(1) processes: $r_t^A = \mu^A + \varphi r_{t-1}^A + k(\eta_t^A + \rho\eta_t^B)$ and $r_t^B = \mu^B + \varphi r_{t-1}^B + k(\rho\eta_t^A + \eta_t^B)$, where η^A and η^B are independently distributed $\text{IID}(0, \sigma_A^2)$ and $\text{IID}(0, \sigma_B^2)$. ρ parameterizes the cross-sectional correlation in housing costs across the two locations, which in our framework is naturally modeled as correlation in the spot rents. If $\rho=0$ the rents, and endogenously the house prices, in A and B are independent; if $\rho=1$ they are perfectly correlated. To control the total magnitude of housing shocks incurred as ρ varies, the scaling constant k can be set to $1/(1+\rho^2)^{1/2}$.²²

²¹ The choice and timing of the move is assumed to be exogenous: the household moves to B with certainty after N years, and knows this from the start of year 0. Allowing for interior probabilities of moving, at various times to various locations, would unduly complicate the model without changing qualitatively the points we would like to make. We note, however, that in the presence of transactions costs, the possibility of being (exogenously) forced to move out of an owned house earlier than expected is an important additional risk associated with owning; whereas renting probably provides more flexibility to adjust to shocks. On the other hand, allowing for endogenous moving could help reduce the risks of both renting and owning, as households can move to a location with lower housing costs.

²² The (conditional) variance of rents in A is $V_A = E_{t-1}(r_t^A)^2 = k^2(\sigma_A^2 + \rho^2\sigma_B^2)$, and similarly the variance of rents in B is $V_B = k^2(\sigma_B^2 + \rho^2\sigma_A^2)$. In the symmetric case with $\sigma_A^2 = \sigma_B^2 = \sigma^2$, using $k=1/(1+\rho^2)^{1/2}$ implies that $V_A = V_B = \sigma^2$, a constant independent of ρ . Also in the symmetric case, the (conditional) correlation between rents r_t^A and r_t^B is $2\rho/(1+\rho^2)$, which monotonically increases in $[0,1]$ with ρ .

The (*ex post*) utility of being a homeowner, again discounting all values back to year 0, is now $U_O = U\left(W - P_0^A + \delta^N (\tilde{P}_N^A - \tilde{P}_N^B) + \delta^{2N} \tilde{P}_{2N}^B\right)$, where the move takes place in year N . The initial purchase price P_0^A in A is observed, but the future sale price P_N^A in A and the purchase and sale prices P_N^B and P_{2N}^B in B are unknown as of year 0 and so impose asset price risk. The utility of being a renter depends on the discounted cost of rents paid in A and then B,

$$U_R = U\left(W - r_0^A - \sum_{t=1}^{N-1} \delta^t \tilde{r}_t^A - \sum_{t=N}^{2N-1} \delta^t \tilde{r}_t^B\right).$$

Suppose that in equilibrium house prices adjust to leave households *ex ante* indifferent between owning and renting, with $E_0 U_O = E_0 U_R$.²³ The equilibrium price P_0^A in A will be forward-looking, taking into account the subsequent move to B. One can show that P_0^A will be a function of the expected present value of rents in A, plus the net risk premium for renting versus owning in A and B ($\pi_R^{AB} - \pi_O^{AB}$), less the discounted risk premium for renting versus owning in B ($\pi_R^B - \pi_O^B$) that is embedded in house prices in B:

$$P_0^A = PV(r_0^A, \mu^A) + \frac{(\pi_R^{AB} - \pi_O^{AB}) - \delta^N (\pi_R^B - \pi_O^B)}{1 - \delta^N} \quad (6)$$

Our discussion will focus on π_O^{AB} , the risk of being a homeowner in A and B. We will only briefly discuss the other terms, since they are analogous to terms in the one-location case above.

The $PV(r^A, \mu^A)$ term has the same form as equation (2), now applied to the rent process in location A. The risk premium for renting in A and B, π_R^{AB} , is analogous to equation (3), but now

²³ We assume a stationary, overlapping generations structure: the next generation is born N years later. The new buyers buy the house in location A from the previous generation, then N years after that buy the house in location B. Whether a household owned or rented in location A, once it gets to location B, the equilibrium price in B is assumed to leave it indifferent between owning and renting in B, as in the one-location case. Generalizing the timing of the one-location case above, P_N^A and P_N^B are assumed to be determined when r_N^A and r_N^B are observed at the start of period N , and P_{2N}^B is determined when r_{2N}^B is observed at the start of period $2N$.

reflects all of the rent shocks η_1^A to η_{2N-1}^A and η_1^B to η_{2N-1}^B that are avoided by owning.²⁴ The “embedded” risk premium $\delta^N (\pi_R^B - \pi_O^B)$ reflects the fact that when the household purchases a house in A, it knows that it will subsequently pay price P_N^B when it moves to B, and that P_N^B will include a net risk premium for the net housing risk avoided by owning while in B, as in the one-location analysis. For instance, if the net risk premium in B is positive, raising the cost P_N^B of buying the second house, to compensate households will lower the price P_O^A they are willing to pay for the first house. Since the household spends its final N years in location B, the risk premia π_R^B and π_O^B take the same form as equations (3) and (4) for a single residence spell of length N , but their effective rent variance is now $\sigma = k^2(\sigma_B^2 + \rho^2\sigma_A^2)$, reflecting the spill-over of the shocks from A into B depending on the correlation ρ . In equation (6) these embedded risk premia are additionally discounted by δ^N since P_N^B is paid in period N .

The risk of being a homeowner, π_O^{AB} , extends the one-location analysis to include the additional asset-price risk from moving and having multiple residence spells:

$$\pi_O^{AB} = \frac{\alpha}{2} \left(\frac{\delta^N}{1 - \delta\varphi} \right)^2 \left\{ \begin{array}{l} \sigma_A^2 \kappa^2 \left([1 - \rho(1 - \delta^N \varphi^N)]^2 \sum_{i=1}^N \varphi^{2(N-i)} + (\rho\delta^N)^2 \sum_{i=N+1}^{2N} \varphi^{2(2N-i)} \right) + \\ \sigma_B^2 \kappa^2 \left([\rho - (1 - \delta^N \varphi^N)]^2 \sum_{i=1}^N \varphi^{2(N-i)} + (\delta^N)^2 \sum_{i=N+1}^{2N} \varphi^{2(2N-i)} \right) \end{array} \right\} \quad (7)$$

Inside the curly brackets the first summation multiplying σ_B^2 (and σ_A^2 respectively),

$$\sum_{i=1}^N \varphi^{2(N-i)} = 1 + \sum_{i=1}^{N-1} \varphi^{2i},$$

captures the effects of the early shocks η_1^B to η_N^B (and η_1^A to η_N^A) on all

three prices P_N^A , P_N^B and P_{2N}^B , depending on the persistence φ of the shocks (as in equation (4))

²⁴ While the renter lives in A only in years 1 to $N-1$, when $\rho > 0$ the later location-A shocks η_N^A to η_{2N-1}^A spill over into the rents r_N^B to r_{2N-1}^B that the renter faces in location B. Similarly, the earlier location-B shocks η_1^B to η_{N-1}^B spill over into the rents r_1^A to r_{N-1}^A the renter faces in location A.

and now also on their cross-sectional correlation ρ . Similarly, the second summation

$$\sum_{i=N+1}^{2N} \varphi^{2(2N-i)} = 1 + \sum_{i=1}^{N-1} \varphi^{2i}$$

captures the effects of the late shocks η_{N+1}^B to η_{2N}^B (and η_{N+1}^A to η_{2N}^A) on

P_{2N}^B . The key new hedging effects are reflected in the terms in square brackets: $H_B =$

$$\left[\rho - (1 - \delta^N \varphi^N) \right]^2 \text{ and } H_A = \left[1 - \rho(1 - \delta^N \varphi^N) \right]^2,$$

where the $\rho-1$ and $1-\rho$ terms reflect a cross-sectional hedge, and the $(1 - \delta^N \varphi^N)$ terms an intertemporal hedge.

Focusing first on the intertemporal hedge, when housing costs in A and B are completely uncorrelated, with $\rho=0$, then $H_B = \left[(1 - \delta^N \varphi^N) \right]^2$. While the shocks η_1^B to η_N^B lead to uncertainty in the purchase price P_N^B in period N , if $\varphi > 0$ this uncertainty is partially offset by their oppositely signed effect on the subsequent sale price P_{2N}^B of the same house, which is discounted by an additional δ^N since the sale takes place N periods later. If prices in B turn out to be high when the household buys in year N , the sale price in year $2N$ would also be expected to be high, dampening the effect on the overall cost of owning. The value of this intertemporal hedge increases with the persistence of rents. If rents are serially uncorrelated, with $\varphi=0$, there is no intertemporal hedge and $H_B = 1$. If rents are a random walk, with $\varphi=1$, but for discounting (and the drift μ) the sale price would in expectation exactly offset the purchase price, reducing the amount of asset price risk, with H_B declining to $\left[(1 - \delta^N) \right]^2$. Also, when $\rho=0$ then $H_A = 1$, reflecting just the effects of the location-A shocks η_1^A to η_N^A on P_N^A , since these shocks would not spillover into prices in location B.

By contrast, turning to the cross-sectional hedge, if housing costs in A and B are perfectly correlated, with $\rho=1$, then $H_B = H_A = \left[(\delta^N \varphi^N) \right]^2$. Notice that the effects of the rent shocks on P_N^A and P_N^B have canceled each other out (as the $\rho-1$ and $1-\rho$ terms canceled), leaving only the lagged effects on P_{2N}^B if the shocks are persistent ($\varphi > 0$). This occurs because, when the household sells its

original house in A, it immediately purchases the new house in B. If rents in the two locations are perfectly correlated, this transaction is a wash sale, providing a cross-sectional hedge akin to moving *within* a local housing market with common prices. On the other hand, once P_N^B washes out it is no longer serving as an intertemporal hedge with P_{2N}^B . Nonetheless one can show that, in the symmetric case with $k = 1/(1+\rho^2)^{1/2}$ and $\sigma_B^2 = \sigma_A^2$, π_O^{AB} is on balance smaller with $\rho=1$ than with $\rho=0$, and as a result P_0^A is larger with $\rho=1$. The cross-sectional correlation in house prices reduces the net risk of owning, justifying higher house prices, *ceteris paribus*.

This analysis assumed that households do not adjust the size of their housing consumption bundles on moving. If we allowed such adjustments, house price fluctuations could actually increase owners' utility. Consider, in a partial equilibrium setting without adjustment costs, the consumption bundles that a household could choose if house prices fluctuate, using a revealed preference argument. If house prices rise, an infinitely-lived household could stay in its existing house and maintain its original level of utility. Or, it could sell its appreciated house, purchase a smaller house, and use the remaining proceeds to consume more non-housing goods, if doing so makes it better off. Conversely, if house prices fall, the household could stay in the existing house and maintain its original level of utility, or substitute toward housing by consuming fewer non-housing goods and buying a bigger house. In either case, by revealed preference, the household is no worse off and might be better off.²⁵

While this analysis of multiple locations is stylized, it illustrates some of the key ways that moving and multiple residence spells affect the risk of home owning and renting. In sum, when housing costs are perfectly correlated cross-sectionally, house-to-house moves do not generate any asset price risk at the time of the move, which effectively extends the homeowners' horizons. The

²⁵ We thank Ed Glaeser for this example.

risk from moving increases as housing costs in the two locations become less correlated. However, even a move to an uncorrelated location is not as risky as it might initially seem because fluctuations in the future purchase price are partially offset by the *subsequent* future sale price, insofar as housing shocks are persistent over time. On the other hand, even a move to a perfectly correlated location entails some asset price risk if the subsequent sale is not also a wash. (In the case of a bequest at death, there will still be asset price risk if the descendants live in an uncorrelated market.) In any case, house prices and the demand for home owning still generally vary with households' expected horizon in a house and local rent risk.

II. Data and variable construction

To test the implications of the model described in section I, we need rent and house price data at the market level and data on homeownership and demographic characteristics at the household level. To this end we combine four data sets.

We obtained an index of median apartment rents by MSA from Reis, a commercial real estate information company.²⁶ The index runs annually from 1981 to 1998, with 47 MSAs observed consistently throughout the sample. Rents are converted to real dollars using the CPI excluding shelter. In light of the available sample period, we measure expected rent growth for an MSA in a given year as the average annual growth rate in rents over the preceding nine years. Similarly the rent variance (σ_r^2) for each MSA-year is the variance in the MSA's de-trended log rents over the prior nine years.²⁷ We use the log of rent to keep MSAs with high rent levels from having artificially high rent variances.

²⁶ Reis collects its data from surveys of owners of "Class A," or top-quality, apartment buildings in each MSA.

²⁷ Specifically, the growth rate of rent is defined as the average change in log rent over the prior nine-year period. Rent variance is then computed using the within-MSA annual differences between the actual log rent and the calculated average growth rate, and thus is expressed as a percentage of the base rent. Using rent variance to measure rent risk is

House price growth is computed in a similar manner for each MSA-year using the Freddie Mac repeat-sales house price index over the same nine-year moving windows. To obtain the level of house prices in a given year, we inflate the MSA's median house price from the 1990 Census by the corresponding growth rate from the Freddie Mac index and convert to real dollars using the CPI excluding shelter. When we estimate the effect of rent variance on the house price-to-rent ratio, we merge the rent and house price data sets by MSA, yielding 44 MSA-level observations per year.²⁸ Due to the nine-year windows over which we estimate rent variance, and the fact that we will always use the one-year lagged rent variance in the analysis, we can estimate rent variance for the 1990-1999 period. This leaves us with 396 MSA-year observations.

Table 1 presents summary statistics on MSA rents and prices. Rent risk is quite substantial. Between 1990 and 1998, the mean (across and within MSAs) standard deviation of real rent was 2.9 percent per year. This is over half of the size of the standard deviation of real house prices, which averaged 4.6 percent over the same period. The variability in rents dwarfed real rent growth: between 1990 and 1998 real rents grew only one-tenth of one percent on average per year. Real house price growth, as well, was approximately zero. The average price-to-rent ratio is 15.7, so homeowners typically pay nearly 16 times the MSA's annual median apartment rent for their houses, though this figure varies considerably across MSAs.²⁹

Most of the sample means are fairly constant over time, exhibiting little difference between the 1990-1998 averages in the first panel of table 1 and the values for 1998 alone in the second panel. For instance, the standard deviation of the rent volatilities is 0.017 for 1990-98 and 0.012

analogous to using income variance to measure income risk, as is done in studies of the effects of income risk on portfolio choice [e.g., Heaton and Lucas (2000)].

²⁸ Of the 47 MSAs with rent data, three do not have matching house price data.

²⁹ Part of the reason that owner-occupied housing commands such a large multiple to rent is that the median house price reflects a greater quantity of (or, equivalently, "nicer") housing than the median apartment rent does. As long as the difference between the amount of housing in the median house and in the median apartment does not spuriously vary across MSAs over time in a way that is correlated with rent variance, it will not affect our estimation.

for 1998. This implies that much of the variation in the data comes from cross-sectional differences across the 44 MSAs rather than from changes over time. In particular, rent risk varies significantly across MSAs, with the volatility of rent ranging from 1.4 percent standard deviation in Fort Lauderdale to 7.2 percent in Austin. In 1998 the rent risks were even larger relative to the house price risks, compared to earlier in the decade: the average standard deviation of real rent in 1998 was 2.3 percent and that of real house prices was 2.8 percent.

Homeownership rates and individual level data are obtained from the 1990 and 1999 CPS March Annual Demographic Supplements.³⁰ The CPS reports whether households own or rent their residences as well as a number of demographic variables such as age, race, education, occupation, marital status, and total household income.³¹ In addition, we impute the probability of a household's staying in the same residence (whether rented or owned) for another year as the proportion of households in the same age-occupation-marital status cell (excluding the household in question) in that year that did not move in the previous year.³² This probability of staying, $P(\text{STAYS})$, will form our proxy for the expected horizon (length of stay in the residence) N , with a high probability of staying corresponding to a high N .³³

The sample averages of the key CPS variables are reported in table 2. In particular, during the sample period 60 percent of the CPS households lived in an owner-occupied house. There is considerable cross-sectional variation in the homeownership rate, especially considering the fact

³⁰ The 1990 and 1999 years divide our rent data into two periods with nine annual observations each. By using these two years, our estimated rent variances (which are based on nine-year rolling windows) will each be generated from a non-overlapping set of underlying rent data.

³¹ We start with more than 110,000 CPS households across both years together. Nearly 70,000 households are dropped because they do not live in one of our 44 MSAs with rent and price data. Approximately 500 more are discarded because the household head is under the age of 25, or they have missing income or mobility information, yielding a net sample size of 40,274 households.

³² For the imputation, we use the entire CPS sample of households, excluding those with heads under the age of 25 or in the military. We form cells, by year, with households within one of seven 10-year age brackets (25-34, 35-44, 45-54, 55-64, 65-74, 75-84, and 85-94), 16 occupations (the CPS's "major occupation" code), and seven marital statuses (the CPS marital status definitions). As is customary, we use the age and occupation of the household head.

³³ We obtain slightly stronger results below if we impose a different functional form and compute N as $1/(1-P(\text{STAYS}))$, instead of as $P(\text{STAYS})$.

that the national average homeownership rate has changed by only 4 percentage points in the last 20 years, from 65 to 69 percent. While 81 percent of households in Richmond own their house, only 33 percent of those in New York City and 53 percent of those in San Jose do.

The last two columns of table 2 report the means for the top and bottom halves of the distributions of the respective variables. This division corresponds to how we will group the data in our empirical work. For example, on average 84 percent of the CPS households did not move in the last year. However, 25 percent ($= 1 - 0.749$) of the “mover” households – those below the median in the imputed probability of not moving – moved in the last year, while only 6.4 percent ($= 1 - 0.936$) of the “stayer” households – those above the median – moved. In the next row, the market-level rent data is matched to each CPS observation based on its MSA of residence. Households who live in “high” rent variance markets have a standard deviation of real rent of 4 percent, twice that of those in “low” rent variance markets.

III. Empirical methodology and results

This section empirically examines the hypothesis that the demand for home owning varies with net rent risk. The model in section I assumed a representative agent and perfectly inelastic housing supply. In that case house prices would fully capitalize the net rent risk premium, leaving all households indifferent between owning and renting. In a more realistic setting with households of different horizons, we need to distinguish between effects that vary across housing markets and those that affect households within markets. At the MSA level, house prices would capitalize the net rent risk premium of the marginal homebuyer. If the marginal homebuyer in a given market has an intermediate horizon such that the rent risk and asset price risk offset each other, the average effect of net rent risk on the demand for owning at the MSA level might be small (assuming the

average household in the data in the market has a similar horizon as the marginal household). If by contrast the marginal homebuyer has a long horizon, then the demand for owning is more likely to increase on average with rent risk. Whether this effect shows up in house prices or homeownership rates (or both) depends on the elasticity of supply of owned houses.³⁴ If supply is relatively elastic (e.g. if new housing units can easily be built, or rental units readily converted to owned condominiums and *vice versa*), then empirically some of the cross-MSA differences in housing demand due to net rent risk would show up in the homeownership rate, but they might not show up in the price of housing. On the other hand, if supply is relatively inelastic, MSA-average net rent risk would show up in the price but possibly not in the homeownership rate. Empirically we will find the latter to be the case.

Independent of any cross-MSA effect, within an MSA, households with a relatively large net exposure to rent risk, in particular households with long expected horizons, should be more likely to own. Since house prices in a market are set by the horizon of the marginal home buyer, households that have a longer horizon than this would find the rent insurance benefit of owning to be relatively attractively priced: By owning they would receive insurance against a larger number of rent risks than the marginal household, and their asset price risk would be more heavily discounted, even though they would pay the same house price premium. Conversely, households with a shorter horizon would receive a smaller rent insurance benefit for the same premium, making owning relatively unattractive. This within-city difference in the tendency to rent versus own should be greatest in high rent-volatility cities, since the magnitude of net risk is proportional to the rent volatility.

³⁴ The literature has not come to a consensus regarding the elasticity of housing supply. Bruce and Holtz-Eakin (1999) and Sinai (1998) find that supply is relatively elastic while Capozza, Green, and Hendershott (1996) argue that it is perfectly inelastic. Glaeser and Gyourko (2004) point out that when demand falls, at least, supply is inelastic because houses are durable.

In this section, we will empirically examine the effect of net rent risk on both the probability of homeownership and the house price-to-rent ratio. Starting with homeownership rates, we first test whether households with exogenously longer expected horizons (“stayers”) are more likely to own in high rent variance places than in low rent variance places, relative to households with short horizons (“movers”). Put another way, does the difference in homeownership rates between households who have long horizons versus short horizons increase with rent variance? We will separately control for the levels of expected horizon (N) and MSA-level rent variance (σ_r^2), and focus on their interaction term ($N\sigma_r^2$). This will minimize any bias due to omitted heterogeneity along either the horizon or MSA dimensions separately. For example, the demand for home owning will tend to increase with the horizon N both because of the rent-risk mechanism of interest here and because of fixed moving/transactions costs associated with buying and selling a house. A household with a shorter horizon in a given location will be less likely to own, in order to avoid the fixed costs. While the model does not formally include transactions costs, our empirical control for horizon will control for all horizon effects, including the number of rent risks incurred and any fixed transactions costs. Since these transactions costs are unlikely to vary systematically with the volatility of rents, the interaction term should reflect only the rent-risk mechanism.

Our second test will focus on the elderly in particular. We will examine whether the difference in the probability of homeownership between elderly households in high and low rent variance markets decreases as the households get older and thus their expected remaining horizon in their residence declines.

Third, we investigate whether households which may be more sensitive to rent risk because average local housing costs comprise a larger share of their budget are more likely to be homeowners in high rent variance markets than in low rent variance markets.

Turning to house prices, we examine the effect of rent variance on the price-to-rent ratio at the MSA level. In markets where rent variance is greater we would expect to see a larger price-to-rent ratio, reflecting the additional value of the rent insurance benefit of homeownership above and beyond the expected present value of the housing service flow. To deal with unobserved MSA-level heterogeneity, we will also look at within-MSA changes in rent variance over time.

III.1 *The effect of rent risk on homeownership rates*

We begin by estimating probit models of the following form using household level data from the 1990 and 1999 CPS:

$$OWN_{i,k,t} = \beta_0 + \beta_1 f(\sigma_r)_{k,t} + \beta_2 g(P(STAYS))_{i,t} + \beta_3 f(\sigma_r) \times g(P(STAYS))_{i,k,t} + \theta X_i + \psi Z_{k,t} + \zeta_t + \varepsilon_{i,k,t} \quad (8)$$

where i indexes the household, k the MSA it lives in, and t the year. OWN is an indicator variable that takes the value one if the household owns its house and zero otherwise. As explained above, equation (8) has separate controls for both the volatility of rent and the household's expected horizon, as well as the interaction of these two variables. The standard deviation of rent in market k is denoted by $\sigma_{r,k}$ and is computed over the 1980-1989 period for the 1990 observations and over 1990-1998 for the 1999 observations. β_1 captures the effect of net rent risk on homeownership for the average household in each MSA. $P(STAYS)_{i,t}$ is the imputed probability that household i does not move during year t , and is our proxy for the horizon N . Our analysis suggests that the probability of owning should increase with horizon and so with $P(STAYS)$, leading to a positive

sign for the coefficient β_2 . However, since other unmeasured factors such as transactions costs can work in the same direction, we will not draw strong inferences from the estimates of β_2 .

The more compelling test of the rent insurance benefit of owning focuses on β_3 and the interaction of rent risk and expected horizon, $f(\sigma_r) * g(P(\text{STAYS}))_{i,k,t}$ in equation (8). The difference in the probability of home owning between longer and shorter expected horizon households is expected to increase with the rent variance, so β_3 is expected to be positive. In addition, while unobserved MSA level characteristics could potentially bias the estimated coefficient β_1 on the standard deviation of rent, the estimated β_3 should still be consistent since it depends only on the interaction of household level characteristics with the MSA-level rent variance. In effect, we are comparing the homeownership probabilities of long- and short-horizon households within each MSA, and in some specifications we add MSA x year fixed effects to make that comparison even more explicit. Thus, in order to affect our results any MSA-level unobservable characteristics would need to influence the homeownership decision for long- and short-horizon households differentially in each MSA, and that differential impact would have to vary across MSAs in a way that happened to be correlated with the rent variance. We believe this to be unlikely.

X_i is a vector of household level controls from the CPS including log income and dummy variables for race, education, occupation, 10-year age categories, and marital status.³⁵ MSA-level controls in the vector $Z_{k,t}$ include the average rent and median house price in the preceding year, and the average real rent growth and house price growth rates over the preceding nine years. A dummy for 1999 is included to control for the year-specific factors ζ_t . For robustness we will

³⁵ We can separately control for marital status, age, and occupation, even while including the probability of staying, since the latter is imputed using the interaction of marital status, age, and occupation rather than the levels of the individual variables.

consider various functional-form transformations of the standard deviation of rent, denoted by $f(\cdot)$, and of the probability of staying, denoted by $g(\cdot)$. Since a number of the independent variables, including the standard deviation of rent, vary only across markets within a given year, we correct the standard errors to account for the correlated shocks within MSA x year cells (unless we directly include MSA x year dummies).

Table 3 starts by estimating the average effect of rent risk on the probability of home owning, restricting β_3 to be zero and estimating β_1 . The most straightforward method is to compare the probability of home owning for households in high rent variance locations versus that for households in low rent variance locations. Thus in the first three columns of table 3, $f(\sigma_r)_{k,t}$ is an indicator variable that is equal to one when $\sigma_{r,k,t}$ is greater than the median standard deviation of rents, which is about 0.027.

Overall, in column 1 the average household in a high rent variance MSA is only slightly more likely to be a homeowner than one that lives in a low rent variance MSA, by $\beta_1 = 2.8$ percentage points. However this effect is not statistically significant (the standard error is 2.4 percentage points). As discussed above, this cross-MSA result could reflect a relatively inelastic supply of owned housing, in which case we would expect to see the average effect of net rent risk instead capitalized into house prices (below). Or, the result could mean that the rent and asset price risks largely offset each other for our sample households with average expected horizons in their respective MSAs, in which case there would be little average effect in either ownership rates or prices.

Households with long expected horizons are more likely to be homeowners. In the first three columns of table 3, $g(P(\text{STAYS}))$ equals one for households above the median imputed probability of staying and zero otherwise. In column 1 the estimated coefficient β_2 implies that

households with the longest horizons, or “stayers”, are 3.6 percentage points more likely to own their homes than are “movers.” Of course, this result could partly reflect transaction costs or other omitted variables that are correlated with horizon.

Column 2 of table 3 reports the results from estimating the full equation (3), now including β_3 . The interaction term is set to one if the household both lives in an MSA with a standard deviation of rent above the median and also is above the median in expected horizon. The resulting estimate of β_3 is 0.042 (0.014), and is statistically significant. Thus, relative to the difference between “movers” and “stayers” in low rent variance MSAs, “stayers” in high rent variance MSAs are 4.2 percentage points more likely to own their home than “movers” in the same places. For comparison, based on the estimate of β_1 , the shorter horizon households (who have an average imputed probability of staying of about 75 percent, or an expected horizon of about four years) are less than one percentage point more likely to own their home if they live in a high rent variance MSA. These results support the hypothesis that, even controlling for MSA characteristics like average house prices and rents, the rent insurance aspect of home owning significantly increases the demand for homeownership for households whose horizons are long enough for the rent risk to outweigh the house price risk.³⁶

Since the horizon/rent-variance interaction term is a combination household/MSA-level effect, we can control for all unobserved MSA characteristics and still identify β_3 . For that purpose, in column 3 we include dummies for each MSA in each year, at the expense of not identifying purely MSA-level characteristics such as the average effect of the standard deviation of rent. Unlike the previous column which made use of the cross sectional variation in rent risk and homeownership rates between MSAs, this strategy uses only the variation from differences in

³⁶ These results are basically unchanged, and still statistically significant, when interactions between the probability of staying and all the observable MSA characteristics (and the year dummy) are included as controls.

homeownership between movers and stayers *within* MSAs. Although the estimated coefficient β_3 on the interaction term declines in magnitude to 2.9 (1.1) percentage points, it remains significant.³⁷

Columns 4 to 6 of table 3 impose a different functional form on the standard deviation of rent and the probability of staying. Instead of using an indicator variable for whether a variable is above some threshold, we include each variable linearly. The interaction term is simply the product $\sigma_r * P(\text{STAYS})$. In the third row of column 5, the estimated coefficient β_3 on the interaction term is 8.08 (2.77) and is statistically significant. The last row of table 3 translates this coefficient into an economically more meaningful number by multiplying it by the standard deviation of the interaction term, 0.011 (table 2). This value can be interpreted as a measure of the exposure to rent risk. The rent insurance benefit of home owning has a large effect on the homeownership rate: a one standard deviation increase in the interaction term, starting at its mean, would increase the probability of homeownership by 9.2 percentage points. Relative to a baseline value of 65 percent, this represents an economically significant effect. When we substitute MSA dummies for the MSA-level covariates, in column 6, the estimated coefficient β_3 declines slightly to 6.10 (1.77), but remains significant.

The estimated coefficients β_1 on the standard deviation of rent σ_r are consistent with the predictions of the model. In column 5, β_1 is negative and significant at -6.29 (2.17), indicating that for the shortest horizon households, the asset price risk outweighs the rent risk, reducing the demand for owning. However, given the positive coefficient β_3 on the interaction term, if the expected horizon is greater than 4.5 years ($1/(1-6.29/8.08)$), the rent risk dominates the asset price risk. This is the case for almost 75 percent of our sample. In sum, the results of this subsection

³⁷ These and subsequent conclusions persist if we also control directly for house price risk; i.e., the standard deviation of house prices computed analogously to rent risk. However, as section I highlights, house price risk is just an endogenous function of rent risk. Our analysis, following equation (1), appropriately captures the net effect of both risks.

indicate that net rent risk significantly affects the demand for owner-occupied housing, with the effect increasing in magnitude with households' horizons, consistent with the analysis of section I.³⁸

III.2 Rent risk and housing demand by the elderly

The value of homeownership as rent insurance may provide a partial explanation for why homeownership rates are high among the “younger” elderly and decline as the elderly become increasingly old. One reason that the (younger) elderly might be more likely to own than younger households is that, as is often assumed, the elderly might be more risk-averse, and so would place a higher value on avoiding net rent risk.³⁹ The model implies that the subsequent decline in homeownership with age could be due to the effect of expected horizon (N) on the net rent risk. For the elderly, their expected remaining lifetime is a reasonable proxy for their expected horizon in their home. Hence as they approach the end of their lives, they expect to face fewer rent shocks, which reduces the benefit of owning in terms of avoiding rent risk, and their asset price risk is much closer at hand. (The asset price risk might be especially salient if they want to bequeath the

³⁸ One implication of the two-location model is that moving to a correlated housing market leads to less asset price risk than moving to an uncorrelated market, since the transaction at the time will be closer to a wash. As long as some fraction of the moves in our data are to at least partially uncorrelated housing markets, our measure of expected mobility captures the potential asset price risk. To check this assumption, we imputed the probability of moving locally and to non-local housing markets. The CPS reports whether a move was within the same county, so we designated within-county moves as local. We used them to compute $P(\text{STAYS,local})$, employing an analogous imputation procedure as for computing $P(\text{STAYS})$ for moving in general. (Though to reflect the fact that differences in the likelihood of local and non-local moves vary by group within MSA, we used MSAs rather than occupations in the imputation cells.) While we do not know which counties households might move to, on average out-of-county moves are more likely to yield lower correlations in housing costs, so we used them to compute $P(\text{STAYS, non-local})$. We included $P(\text{STAYS,local})$ and $P(\text{STAYS,non-local})$ and each of their interactions with σ_r as explanatory variables in equation (8). While for brevity we do not report the results, the coefficient on the interaction of rent variance with $P(\text{STAYS,non-local})$ is positive and statistically significant, while the interaction with $P(\text{STAYS,local})$ is indistinguishable from zero. These results persist even in the presence of MSA \times year dummies, and are consistent with section I.

³⁹ This assumes that the younger elderly have a long enough remaining horizon such that the net risk premium starts positive. Note that young households do not necessarily have longer expected horizons in their residences (N) than the younger elderly, since horizon and remaining lifetime do not coincide as closely for the young.

monetary proceeds from selling their home at death to their children). Thus even if the younger elderly are relatively likely to own (a level effect), we expect to find that their probability of owning should decline as they approach the end of their lifetime (a slope effect).

While one could attribute a rising-then-falling age-profile of homeownership to the rent insurance benefit of owning, there are many other possible explanations. For example, low mobility among the younger elderly might explain their higher homeownership rates, and declining health that requires nursing-home care might cause them to be more likely to move out as they further age. However, a unique prediction of our model is that the age-profile effects due to the rent insurance mechanism should be magnified by the volatility of rents. For instance, risk aversion-induced homeownership by the (younger) elderly, as well as the difference in homeownership rates between them and younger households, should be greatest in high rent variance places, since the value of the rent insurance would be largest there. Also, the decline in the probability of homeownership with age should be steepest in high rent variance locations, since the insurance benefit (which increases with the interaction term $\sigma_r^2 \times N$) is more sensitive there to the expected horizon. Other mechanisms affecting the age-ownership profile are unlikely to be systematically different in high and low rent volatility MSAs. Thus we will focus our attention on how the slope of the age profile of homeownership varies with rent volatility.⁴⁰

The effects of rent volatility can be directly seen in the unconditional homeownership rates by age. Using the pooled 1990 and 1999 CPS cross-sections, we divided our 44 MSAs into high- and low-variance markets depending upon whether they were in the top quartile of rent variance or

⁴⁰ We do not expect differences in the level of homeownership to be very well-identified in the cross-section, so we will concentrate on differences in the slope of the age profile. For example, as the elderly approach the end of life, assuming they value the terminal value of their house (perhaps due to the aforementioned bequest motive), the net rent risk could become negative if the asset price risk outweighs the few remaining rent risks. In that case, the older elderly in high rent volatility places would be more likely to be *renters* than those in low rent volatility MSAs, *ceteris paribus*. That negative relationship is a result of those households in high rent volatility MSAs having experienced a more rapid decline in their rate of homeownership. This difference in slope is less likely to be contaminated by MSA heterogeneity than is the level of homeownership.

below the median, and used a kernel regression to compute the unconditional homeownership rate by age in both sets of markets.⁴¹ The result is presented in figure 1. By age 40, homeownership rates are about 3 percentage points greater in high rent variance MSAs than in low rent variance MSAs. The difference grows with age and peaks for people in their early 60s, with 60-year-olds exhibiting homeownership rates of 76 percent in high rent variance MSAs and 72 percent in low rent variance MSAs (the level effect). While the unconditional probability of homeownership declines with age starting in the late 60s, it does indeed fall faster for people in high rent variance MSAs (the slope effect), consistent with the rent insurance mechanism. By the time people are in their late 70s, with presumably short expected remaining lifetimes, the probabilities of homeownership in high- and low-rent variance MSAs have converged to approximately the same level.

While figure 1 presents unconditional homeownership rates by age, we would like to control for other observable factors that may vary systematically by age or with rent variance. We test these hypotheses with a more parametric specification by estimating the following spline equation using a probit model:

$$OWN_{i,k,t} = \gamma_0 + \gamma_1 AGE \times UNDER60_i + \gamma_2 OVER60_i + \gamma_3 AGE \times OVER60_i + \gamma_4 f(\sigma_r)_{k,t} + \gamma_5 AGE \times UNDER60 \times f(\sigma_r)_{i,k,t} + \gamma_6 OVER60 \times f(\sigma_r)_{i,k,t} + \gamma_7 AGE \times OVER60 \times f(\sigma_r)_{i,k,t} + \theta X_i + \psi Z_{k,t} + \zeta_t + \varepsilon_{i,k,t} \quad (9)$$

where AGE is the age in years of the head of the household, UNDER60 is an indicator variable that takes the value of one if the head is 60 years old or younger, OVER60 is an indicator variable that takes the value of one if the head is more than 60 years old. In some specifications, $f(\sigma_r)_{k,t}$ is a dummy variable that equals one if MSA k in year t is in the top quartile of rent variance and zero otherwise. In other specifications, it is the standard deviation of rent entered linearly. The terms

⁴¹ Given the relatively small number of elderly in the data, this section emphasizes the top quartile of rent variance in order to make its points more starkly. The results are qualitatively similar using the top 50 percent.

that are not interacted with $f(\sigma_r)_{k,t}$ (those with coefficients γ_0 to γ_3) correspond to the dashed line in figure 1 (low rent variance). The terms that are interacted (γ_4 to γ_7) measure the differences in level and slope between the solid line in figure 1 (high rent variance) and the dashed line. The hypothesis that the younger elderly are in general more risk averse concerning rent volatility implies that γ_6 should be positive (the level effect). Further, if the age-ownership profile is more steeply declining in high volatility MSAs, γ_7 should be negative (the slope effect). Once again, the specification includes detailed household controls X_i for income, year, race, education, occupation, expected mobility, and marital status, as well as MSA x year dummies.

The results appear in table 4. The most direct test of the rent insurance mechanism focuses on just the elderly, and thus column 1 uses only those households where the respondent is over the age of 60. By including MSA x year effects, we are comparing the slopes of the post-60 age-homeownership profile in high and low rent variance MSAs but are controlling for differing levels of homeownership across MSAs and over time. The results are consistent with the rent insurance mechanism. Most notably, γ_7 is significantly negative, implying that homeownership declines more rapidly with age in high rent variance MSAs. Relative to people over 60 in low rent variance MSAs, the probability of homeownership for people over 60 in high rent variance MSAs falls by 0.29 (0.14) percentage points more per year of age. This is a considerable difference because, controlling for other covariates, the probability of homeownership for people over 60 in low rent variance MSAs is nearly constant over their remaining lifetimes.

In column 2, we include in the sample households of all ages and constrain the coefficients on the covariates to be the same for the entire sample. We again include MSA x year fixed effects. As a baseline, based on γ_1 , households aged 60 or below in low rent variance MSAs (in the bottom three quartiles) have a probability of homeownership that increases at a rate of 1.4 percentage

points per year. In high rent variance MSAs (the top quartile), the probability of homeownership rises by $\gamma_5 = 0.16$ (0.07) percentage points faster than this per year, so that by age 60 households are $\gamma_6 = 10.4$ (3.3) percentage points more likely to be homeowners than people of the same age in low rent variance MSAs. Thus homeownership among the younger elderly rises with rent volatility. We find virtually the same relative effect for over-60 households as we did before: since γ_7 is significantly negative, the probability of homeownership declines more rapidly with age for households in high rent variance MSAs.⁴²

These results are generally robust to specification changes. The last two columns in table 4 instead parameterize rent variance as a continuous linear function. We obtain similar qualitative effects as in the previous columns, although the interaction of rent variance with age-over-60 (γ_7) is no longer statistically significant.⁴³

III.3 Rent risk and the market rent-to-income ratio

Households for whom housing is a larger portion of their budgets or wealth might be more sensitive to net rent risk since they are implicitly taking a larger gamble, and so might be effectively more risk averse. We test this “budget share” hypothesis by dividing the sample based on the ratio of the average rent in the MSA to actual household income. We use MSA-level rent instead of the household’s own rent since the former is exogenous to the household and is defined

⁴² The only notable difference between columns 1 and 2 is that in column 2 households over age 60 in low rent variance places have homeownership rates that increase with age (γ_3). This result is an artifact of not allowing an MSA/year-specific over-60 intercept, as we did in column 1, and constraining the effects of the covariates to be the same for young and old households. This is why we place our emphasis on the *difference* in slopes between high and low rent variance places, which is better identified than the slopes themselves.

⁴³ We have also estimated a quadratic age profile of homeownership, and allowed this profile to be different in high- and low-variance MSAs. Again, younger elderly in high rent variance MSAs have a higher overall probability of homeownership, but still exhibit a steeper decline with age, with the differences being statistically significant. We have also replaced the “over 60” indicator with an indicator variable for the household’s head being retired, with similar qualitative results.

even for homeowners. Households that live in markets where rents are high relative to their own incomes would generally need to spend more of their budget on housing to obtain the same housing service flow relative to households that live in low rent markets.

The average effect of the rent-to-income ratio interacted with rent volatility on the probability of homeownership is uncertain, since the effect depends on whether rent risk or house price risk dominates for the average household. However, we expect that the demand for owning would still increase with horizon more rapidly for high market rent-to-income households. Further, homeownership rates should be highest among those with high rent-to-income ratios, long expected horizons, and high rent risk (i.e., interacting all three terms). As before, we estimate a probit model on household level data from the 1990 and 1999 CPS:

$$\begin{aligned}
 OWN_{i,k,t} = & \rho_0 + \rho_1 f(\sigma_r)_{k,t} + \rho_2 h(r/Y)_{i,k,t} + \rho_3 f(\sigma_r) \times h(r/Y)_{i,k,t} + \rho_4 g(P(STAYS))_{i,t} \\
 & + \rho_5 g(P(STAYS)) \times h(r/Y)_{i,k,t} + \rho_6 f(\sigma_r) \times g(P(STAYS))_{i,k,t} \\
 & + \rho_7 f(\sigma_r) \times g(P(STAYS)) \times h(r/Y)_{i,k,t} + \theta X_i + \psi Z_{k,t} + \zeta_t + \varepsilon_{i,k,t}
 \end{aligned} \tag{10}$$

where r/Y is the MSA-rent to household-income ratio. The other variables are defined as in the previous subsections. As before, we will estimate two specifications. First, we estimate a discretized specification where high rent variance and “stayer” households are defined relative to their respective medians, and high rent-to-income households are those in the top quartile.⁴⁴

Second, we let each of the variables enter linearly.⁴⁵ All regressions include the usual household

⁴⁴ This cutoff roughly corresponds to households for whom average rents equal a third of their annual incomes. That is the budget allocation to housing typically recommended by financial planners.

⁴⁵ For this specification we symmetrically trim the top and bottom one percent of the rent-to-income distribution since households with zero or very low values for income appear to have very high rent-to-income ratios and so could potentially skew the results. This sampling reduces our number of observations to 39,468 from 40,274 households. Predictably, this sampling has virtually no effect on any of the estimated coefficients in the discretized specification in columns 1 and 2. It also has little effect on the triple-interaction term in columns 4 and 6, but reduces the magnitude of the rent-to-income level and double-interaction terms.

controls, and MSA x year dummies which again subsume the uninteracted rent variance coefficients ρ_1 .

The results are reported in table 5. In column 1, we estimate the differential effect of rent variance and horizon on high and low market rent-to-income households. The results are consistent with the budget-share hypothesis. First, according to the estimate for ρ_5 , stayers who are in the high rent-to-income group are 4.4 percentage points more likely to be homeowners than movers in that group, relative to the difference in probability of homeownership between stayers and movers with low rent-to-income ratios. Second, the estimated ρ_6 implies the same result as in table 3: households with longer horizons are more sensitive to rent risk. Stayers in high rent variance areas are 3.2 percentage points more likely to be homeowners than are movers, relative to stayers and movers in low rent variance areas. Both of these estimated coefficients ρ_5 and ρ_6 are statistically significant. Also, households who live in markets where rent-to-income ratios are in the top quartile are $\rho_2 = 3.5$ percentage points less likely to own their homes than households with low ratios.

In column 2 of table 5, we test the triple-interaction effect ($N \times \sigma_r \times r/Y$): Are the highest homeownership rates exhibited by households in high rent volatility MSAs, with long expected horizons, and with high market rent-to-income ratios? Indeed, that is what we find. Such households are $\rho_7 = 5.4$ percentage points more likely to be homeowners, a statistically significant effect. This triple-interaction specification controls for unobserved differences between movers and stayers, high rent variance MSAs and low variance MSAs, and high rent-to-income and low rent-to-income households. It even allows for unobserved differences within the corresponding binary interactions: moving/staying and rent variance, rent variance and rent-to-income, and

moving/staying and rent-to-income. The MSA x year effects control for unobserved MSA-level characteristics that change over time.

In columns 3 through 6, we use different functional forms of the key variables to demonstrate the robustness of the results. In columns 3 and 4, we continue to use an indicator variable for high and low rent-to-income households but now let the standard deviation of rent and the probability of staying enter linearly. Since rent/income can be quite high for households with very low income, using a dummy for r/Y reduces the impact of the measurement error. In column 3, the significant results are that homeownership increases with expected horizon (N), and with the sensitivity to rent risk ($N^*\sigma_r$). These results are consistent with those in table 3. In column 4, we still find that rent risk increases the likelihood of homeownership most for households who expect to be in their houses longer ($N^*\sigma_r$). This effect is increasingly pronounced as the rent-to-income ratio increases: in the last row, the estimated coefficient on the triple-interaction term is $\rho_7=9.4$ (4.4). Columns 5 and 6, which also enter rent-to-income linearly, produce qualitatively similar results, though the statistical significance of the triple interaction term in column 6 is diminished.

III.4 The effect of rent risk on the price-to-rent ratio

In this subsection we look for effects of the rent-insurance demand for home owning on house prices. We estimate the following equation in MSA-level panel data using OLS:

$$\left(\frac{P}{r}\right)_{k,t} = \kappa_0 + \kappa_1\sigma_{r,k,t} + \psi Z_{k,t} + \zeta_t + u_{k,t}, \quad (6)$$

where $(P/r)_{k,t}$ is the price-to-rent ratio in MSA k in year t , $\sigma_{r,k,t}$ is its standard deviation of rent, and $Z_{k,t}$ is its growth rate of real rent. Since the rent $r_{k,t}$ in the denominator of the dependent variable controls for the overall demand for living space, the rent insurance value of ownership should show

up as a larger price-to-rent ratio (assuming the supply of owner-occupied housing is not fully elastic). That is, using the ratio of prices to rents controls for shocks to the overall housing market, which impact both owner-occupied housing and rental housing. Just as a price-earnings ratio for stocks should be higher for firms with higher expected future earnings growth, P/r should be higher for MSAs with higher expected future rent growth. Controlling for the growth rate of rent, the coefficient κ_1 on the standard deviation of rent will then capture the net rent risk premium associated with net rent risk, as discussed in section I. Differences over time that are common to all MSAs are controlled for using the year dummies ζ_t .

We estimate this model on the panel of 44 MSAs observed over the 1990-1998 time period. For each year $t=1990-1998$, we calculate real rent variance and growth over the prior (rolling) nine-year period. For example, for 1990 $\sigma_{r,k}$ and rent growth are calculated over 1981-1989, and for 1998 they are calculated over 1989-1997.

Table 6 reports the results. We find consistent evidence that the rent insurance benefit of owner-occupied housing is capitalized into larger price-to-rent ratios. Column 1 of table 6 presents the results from the pooled cross section, without MSA fixed effects. First, the price-to-rent ratio significantly increases with real rent growth, with an estimated coefficient of 69.0 (14.7). Hence house prices capitalize future rents, as expected. Also as expected, MSAs with more volatile rents have a significantly greater price-to-rent ratio, with the estimated coefficient κ_1 being 34.5 (11.9). The last row of table 6 helps to gauge the economic significance of this result. A one standard deviation increase in $\sigma_{r,k,t}$ is estimated to increase the price-to-rent ratio by 0.62. Since the mean price-to-rent ratio is 15.7, this amounts to a 3.9 percent rise in house prices, holding rents constant, which is a sizable effect. Thus, house prices appear to incorporate both expected future rents and

the associated risk premia, consistent with the model in section I, and more generally with asset-pricing models of other, financial assets.

We next incorporate MSA fixed effects to control for all MSA-level characteristics that do not change over time. Since the specification also includes year dummies, we are using the within-MSA variation in rent volatility, rent growth, and the price-to-rent ratio over time to identify the rent insurance mechanism. (Recall that the rent variance $\sigma_{r,k,t}$ and (rent growth) $_{k,t}$ within an MSA change over time as the rolling window over which we compute them moves.) However, the MSA dummies remove a potentially powerful source of variation in rent variance, average differences across MSAs.⁴⁶

Even controlling for MSA and year fixed effects, in column 2 we find that when rent variance in a given MSA is larger, the price-to-rent ratio is in fact higher. The estimated coefficient $\kappa_1 = 11.0$ (5.6) implies that a one standard deviation increase in $\sigma_{r,k,t}$ leads to a 0.20 increase in the price-to-rent ratio (last row). Although smaller than in the previous column, this still implies a 1.3 percent increase in house prices (from the base P/r ratio of 15.7) for a given rent level, and is statistically significant. The smaller magnitude is not surprising considering that only within-MSA variation is being used for identification. Rent growth also continues to have the expected positive effect on P/r, with an estimated coefficient of 16.7 (4.7). In column 3, we account for MSA level heterogeneity by estimating equation (4) in first differences. This specification emphasizes new information that arrives over time, since the difference in the computed rent variance between one year and the previous year is due to adding the most recent year of data and discarding the oldest

⁴⁶ Note that one would not expect to find as strong of an effect of rent variance on the probability of home owning within MSAs over time, since homeownership and housing construction are slow to respond to changes in rent variance. However, since prices adjust more readily, changes in rent variance should be more quickly incorporated into prices and thus be more easily detectable in the data on price-to-rent ratios.

year in the rolling window used to calculate σ_r . The results are almost identical to those in column 2, although more precisely measured, with the estimated coefficient κ_1 being 10.1 (3.8).⁴⁷

Overall, these results show that at least some of the rent insurance benefits of homeownership are capitalized into local price-to-rent ratios, even for the average household. These results are consistent with the model in section I, assuming that the supply of owned housing is at least partially inelastic, and suggest that the net rent risk premium is positive for our sample households with average expected horizons in their respective MSAs.

IV. Conclusion

Since every household needs to obtain housing services somehow, house price risk and rent risk cannot be studied in isolation. One frequently overlooked but important benefit to homeownership is the insurance that it provides against the risk of fluctuations in future rent payments. Homeownership provides a guaranteed level of housing services for a fixed up-front cost. In contrast, renters purchase housing services on the risky spot rent market. While homeownership provides a hedge against this rent risk, it is itself risky because owners eventually move or die and thus face asset price risk at the time of sale. However, this asset price risk is lower than conventionally assumed. In particular, it is smaller for households with longer effective horizons in their homes – either because they plan to live there a long time, or they will move within the same housing market or to a correlated market, or they will bequeath their homes to heirs who plan to live in the same or correlated housing markets. In addition, fluctuations in house prices generally reflect changes in the present value of future rents, and so in the costs of fulfilling

⁴⁷ These results persist even when we separately control for the standard deviation of house prices, even though, as noted above, it is an endogenous function of rent variance in our framework.

households' short positions in housing. This reduces the aggregate wealth effects from house price fluctuations.

We presented a simple model of tenure choice with endogenous house prices and both rent risk and house price risk. The demand for homeownership increases with rent risk, given house price risk. Even with endogenous house prices, such that house price risk increases with rent risk, demand still increases on net with rent risk for people with long enough expected horizons. These people avoid a greater number of rent risks by owning, and their future asset price risk is more heavily discounted. Thus the model suggests that the insurance demand for homeownership will increase on net with households' expected horizon, and with the interaction of horizon with rent risk.

We tested these implications by investigating the effect of rent volatility on the probability of home owning and on house prices. We controlled for MSA-level heterogeneity and other factors by comparing households that should be differentially affected by rent variance only because they have different expected horizons in their residences. This isolated the effect of rent risk from other factors that influence homeownership, including transactions costs and other factors correlated with horizon or rent variance separately. Notably, we found that households with longer horizons are indeed more likely to own in high rent variance MSAs than in low rent variance MSAs, relative to households with shorter horizons, as suggested by the model. A one standard deviation increase in the exposure to rent risk (expected horizon interacted with the standard deviation of rent) is estimated to lead to a 7 to 9 percentage point increase in the homeownership rate. Also consistent with the model, the younger elderly are particularly sensitive to rent risk, with people aged 60 residing in MSAs with a top-quartile rent variance being over 10 percentage points more likely to be homeowners than people of the same age in low rent variance MSAs. Confirming that this

effect is due to rent risk, the probability of homeownership drops most rapidly with age for elderly who live in high rent variance MSAs, consistent with the rent insurance benefit declining with their expected horizon. Also, households for whom market rents are high relative to their incomes respond the most to rent risk, especially if their expected horizon is large.

We also found evidence that some of the insurance demand for home owning shows up in the multiple of rents people are willing to pay for houses. Even controlling for MSA-level fixed effects, we found that when MSAs have higher rent variance their house prices are larger relative to the rental value of the housing stock. That is, house prices reflect not only expected future rents, but also the associated rent-risk premia, consistent with asset-pricing models of financial assets.

These results have a number of implications for housing markets and other decisions for which housing wealth is important, in addition to the aggregate wealth effect already discussed. The rent insurance benefit of owning appears to be a significant factor in the demand for homeownership. For comparison, a typical cross-sectional estimate of the user cost elasticity of owning implies that a one standard deviation increase in user cost would lead to about a 2.5 percentage point rise in the homeownership rate. The estimated effect in table 3 of a one standard deviation increase in the effective rent variance is about three times larger.

Another way to gauge the economic significance of the results is to calculate how much rent risk contributes to homeownership rates and house prices overall. Using our estimates from the fifth column of table 3, we computed the effect of eliminating rent variance altogether (relative to its actual level) on the predicted probability of homeownership. For the 75 percent of our sample households with the longest expected horizons, the likelihood of homeownership would significantly decrease in the absence of rent variance, on average by 3.3 percent, as the net rent risk avoided by owning is eliminated. For the remaining households, who have short horizons, the

probability of homeownership would increase by as much as 10 percent if rent risk were eliminated, since for them the asset price risk dominates the rent risk. The effect of rent risk on house prices, computed from our estimates in table 6, also is large. Using the smaller estimates from the second column, if there were no rent risk then house prices relative to rents would decline by 2.3 percent on average and by as much as 7 percent in some MSAs.

For older households, the rent insurance aspect of home owning may help explain why the elderly avoid becoming renters and why, if they do, they usually do so very late in life. Because they highly value the insurance against rent risk, it is more costly for the younger elderly to become renters than previous analyses have assumed. But as the elderly further age, the asset price risk of owning can eventually dominate the risk from renting, making them increasingly likely to become renters late in life. These findings underscore the need for viable reverse mortgage markets to enable households to avoid both rent and asset price risk by continuing to own their houses while annuitizing their housing wealth. To date, these markets have not been particularly successful [Caplin (2001)]. In their absence, one should not simply assume that the housing wealth of the elderly is available for consumption.

References:

- Bajari, Patrick, C. Lanier Benkard, and John Krainer. "House Prices and Consumer Welfare," *Mimeo*, May 2003.
- Ben-Shahar, Danny. "On the Optimality of the Hybrid Tenure Mode," *Journal of Housing Economics*, vol. 7 (1998), pp.69-92.
- Berkovec, James and Don Fullerton. "A General Equilibrium Model of Housing, Taxes, and Portfolio Choice." *Journal of Political Economy*, vol. 100 (2), April 1992, pp. 390-429.
- Bruce, Donald and Douglas Holtz-Eakin. "Fundamental Tax Reform and Residential Housing Values," *Journal of Housing Economics*, 8(4): 249-271, 1999
- Brueckner, Jan. "Consumption and Investment Motives and the Portfolio Choices of Homeowners." *Journal of Real Estate Finance and Economics*, vol. 15, September 1997, pp. 159-180.
- Campbell, John, and Joao Cocco. "Household Risk Management and Optimal Mortgage Choice." *Quarterly Journal of Economics* 118:1449-1494, November 2003.
- Caplin, Andrew. "The Reverse Mortgage Market: Problems and Prospects." *Innovations in Housing Finance for the Elderly*, Olivia Mitchell, ed. Pension Research Council (2001).
- Capozza, Dennis R., Richard Green and Patric H. Hendershott. 1996. "Taxes, Home Mortgage Borrowing and Residential Land Prices" in Aaron and Gale (eds.), *Fundamental Tax Reform*, The Brookings Institution, Washington D.C., 181-204.
- Case, Karl, John Quigley, and Robert Shiller. "Comparing Wealth Effects: The Stock Market Versus the Housing Market," *Mimeo, UC Berkeley*, May 2003.
- Case, Karl, and Robert Shiller. "The Efficiency of the Market for Single-Family Homes." *American Economic Review*, vol. 79 (1), March 1989, pp. 125-137.
- Chan, Sewin. "Spatial Lock-In: Do Falling House Prices Constrain Residential Mobility?" *Journal of Urban Economics*, vol. 49 (3), May 2001, pp. 567-586.
- Cocco, Joao. "Hedging House Price Risk with Incomplete Markets." *Mimeo, London Business School*, September 2000.
- Davidoff, Thomas. "Labor Income, Housing Prices, and Homeownership." *Mimeo, UC Berkeley*, April 2003.
- Engelhardt, Gary. "Consumption, Down Payments, and Liquidity Constraints." *Journal of Money, Credit, and Banking*, 28:2 (May) 1996: 255-271.

- Flavin, Marjorie and Takashi Yamashita. "Owner-Occupied Housing and the Composition of the Household Portfolio Over the Life Cycle." *American Economic Review*, forthcoming.
- Flavin, Marjorie and Shinobu Nakagawa, "A Model of Housing in the Presence of Adjustment Costs: A Structural Interpretation of Habit Persistence," *Mimeo*, October 2003.
- Fratantoni, Michael. "Housing Wealth, Precautionary Saving, and the Equity Premium." *Mimeo, Fannie Mae*, July 1997.
- Genesove, David. "The Nominal Rigidity of Apartment Rents." *NBER Working Paper #7137*, May 1999.
- Genesove, David, and Christopher Mayer. "Equity and Time to Sale in the Real Estate Market." *American Economic Review*, vol. 87 (3), June 1997, pp. 255-269.
- Glaeser, Edward and Joseph Gyourko. "Urban Decline and Durable Housing," *Wharton Real Estate Center Working Paper #382*, August 2004.
- Gyourko, Joseph and Joseph Tracy. "Using Home Maintenance and Repairs to Smooth Variable Earnings," *Wharton Real Estate Center Working Paper #432*, March 2004.
- Goetzmann, William. "The Single Family Home in the Investment Portfolio." *Journal of Real Estate Finance and Economics*, Vol. 6 (3) p. 201-22. May 1993.
- Haurin, Donald. "Income Variability, Homeownership, and Housing Demand." *Journal of Housing Economics*, March 1991, 1 (1), 60-74.
- Heaton, John, and Lucas, Deborah, "Portfolio Choice and Asset Prices; The Importance of Entrepreneurial Risk," *Journal of Finance*, LV(3), June 2000, 1163-1198.
- Hendershott, Patric and Joel Slemrod. "Taxes and the User Cost of Capital for Owner-Occupied Housing." *AREUEA Journal*, Winter 1983, 10 (4), 375-393.
- Henderson, J.V. and Ioannides, Y.M. "A Model of Housing Tenure Choice." *American Economic Review*, Vol. 73 (1), p. 98-113, March 1983.
- Jappelli, Tullio. "Who is Credit Constrained in the U.S. Economy?" *Quarterly Journal of Economics*, 105, pp. 219-234, February 1990.
- Jappelli, T., Pischke, S., and Souleles, N. "Testing for Liquidity Constraints in Euler Equations with Complementary Data Sources." *Review of Economics and Statistics*, 80(2), May 1998, pp. 251-262.
- Megbolugbe, Sa-Aadu, and James Shilling. "Oh, Yes, the Elderly Will Reduce Housing Equity under the Right Circumstances." *Journal of Housing Research*, vol. 8 (1) p.53-74, 1997.

- Ortalo-Magné, François and Sven Rady. "Tenure Choice and the Riskiness of Non-housing Consumption," *Journal of Housing Economics*, vol. 11 (2002), 266-279.
- Ortalo-Magné, François and Sven Rady. "Homeownership: Low household mobility, volatile housing prices, high income dispersion," *University of Wisconsin Working Paper*, November 2002.
- Poterba, James. "Tax Subsidies to Owner-Occupied Housing: An Asset Market Approach." *Quarterly Journal of Economics*, November 1984, 99 (4), 729-752.
- Poterba, James and Andrew Samwick. "Household Portfolio Allocation Over the Life Cycle," *NBER Working Paper #6185*, September 1997.
- Rosen, Harvey. "Housing Decisions and the U.S. Income Tax." *Journal of Public Economics*, February 1979, 11 (1), 1-23.
- Rosen, Harvey, Kenneth Rosen, and Douglas Holtz-Eakin. "Housing Tenure, Uncertainty, and Taxation." *Review of Economics and Statistics*, vol. 66, no. 3 (August 1984), pp.405-416.
- Sinai, Todd. "Are Tax Reforms Capitalized into House Prices?" *mimeo*, The Wharton School, December 1998.
- Skinner, Jonathan. "Housing Wealth and Aggregate Saving," *Regional Science and Urban Economics*, Vol. 19 (2), p.305-24, May 1989.
- Skinner, Jonathan. "Is Housing Wealth a Sideshow?" in David Wise, ed, *Advances in the Economics of Aging*, NBER, University of Chicago Press, 1996 (pp241-68)
- Stein, Jeremy. "Prices and Trading Volume in the Housing Market: A Model with Downpayment Constraints." *Quarterly Journal of Economics*, vol. 110 (2), May 1995, pp.379-406.
- Summers, Lawrence. "Inflation, the Stock Market, and Owner-Occupied Housing." *American Economic Review*, vol. 71 (2), May 1981, pp. 429-434.
- Venti, Steven and David Wise. "Aging and Housing Equity." *NBER Working Paper #7882*, September 2000.
- Zeldes, Stephen P. "Consumption and Liquidity Constraints: An Empirical Investigation." *Journal of Political Economy*, 97, pp. 305-346, 1989.

Table 1: Summary statistics for MSA-level data

Variable	1990-1998		1998 only	
	Mean	Std. Dev.	Mean	Std. Dev.
Standard deviation of real rent	0.029	0.017	0.023	0.012
Standard deviation of real house price	0.046	0.031	0.028	0.016
Real rent growth	0.001	0.019	0.002	0.013
Real house price growth	0.006	0.031	-0.001	0.021
Average real rent	6,331	1,505	6,748	1,607
Median real house price	102,773	49,841	107,527	48,415
Price-to-rent ratio	15.72	4.08	15.52	3.57
Number of observations	396		44	

Notes: The first panel reports the average for all MSAs over the 1990-1998 time period. The second panel reports the average across the 44 MSAs in 1998 only. The standard deviations of rent and house prices, rent growth, and house price growth are all computed over the preceding nine years. The rent data are obtained from Reis. House price growth is computed from the Freddie Mac repeat sales house price index. To compute the level of house prices, the MSA median house price from the 1990 Census is inflated to the current year using the Freddie Mac index. All dollar values are in real (1990) dollars, deflated by the CPI less shelter.

Table 2: Summary statistics for CPS data (1990 and 1999)

	Mean	Standard Deviation	Mean if below the median	Mean if above the median
Proportion owning	0.600	0.490		
Proportion not moving (actual P(STAYS))	0.843	0.363		
Proportion not moving (imputed P(STAYS))	0.843	0.116	0.749	0.936
Standard deviation of real rent	0.031	0.013	0.021	0.040
Probability of not moving x standard deviation of real rent	0.026	0.011		

Notes: Number of household-level observations is 40,274 from the 1990 and 1999 CPS. Rent variances are computed over the 1980-1989 and 1990-1998 time periods. The rent data are obtained from Reis. Not moving is defined as having not moved in the preceding year.

Table 3: The effect of net rent risk on the probability of homeownership

	(1)	(2)	(3)	(4)	(5)	(6)
	Indicator variables for high rent variance and high probability of staying			Continuous variables		
Standard deviation of real rent (σ_r) [β_1]	0.028 (0.024)	0.008 (0.022)		0.339 (0.686)	-6.285 (2.174)	
Probability of staying P(STAYS): (N) [β_2]	0.036 (0.011)	0.015 (0.013)	0.020 (0.011)	0.652 (0.070)	0.395 (0.095)	0.448 (0.081)
P(STAYS) x s.d. of real rent ($N \times \sigma_r$) [β_3]		0.042 (0.014)	0.029 (0.011)		8.081 (2.771)	6.100 (1.772)
MSA controls	Yes	Yes	No	Yes	Yes	No
MSA x year dummies	No	No	Yes	No	No	Yes
Household controls	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-squared	0.2352	0.2355	0.2498	0.2371	0.2375	0.2520
A one standard deviation in staying x σ_r leads to...					0.092 (0.032)	0.069 (0.020)

Notes: Estimated coefficients are marginal effects from probit regressions of equation (3) estimated on 40,274 households in 44 MSAs in 1990 and 1999. The dependent variable takes the value of one if the household is a homeowner. All specifications include year dummies. MSA controls include median real rent, median real house price, real rent growth, and real house price growth. Household controls include log household income and dummies for the head's occupation, age, race, education, and marital status. MSAs are deemed to have high rent variance if σ_r is above the median household's value of 2.8 percent. The probability of staying is high if the household is above the median probability of 88 percent. All dollar values are in real (1990) dollars, deflated by the CPI less shelter. For specifications that do not include MSA x year dummies, the standard errors, in parentheses, are adjusted for correlation within MSA/year.

Table 4: Net rent risk and homeownership by the elderly

	(1)	(2)	(3)	(4)
	Indicator variable for high rent variance		Continuous rent variance	
Age if 60 or below [γ_1]		0.0141 (0.0005)		0.0086 (0.0009)
Age if 60 or below $\times \sigma_r$ [γ_5]		0.0016 (0.0007)		0.056 (0.025)
Age > 60 dummy [γ_2]		0.557 (0.010)		0.414 (0.029)
Age > 60 dummy $\times \sigma_r$ [γ_6]		0.104 (0.033)		3.598 (1.303)
Age if over 60 [γ_3]	-0.0006 (0.0007)	0.0019 (0.0009)	-0.0006 (0.0016)	0.002 (0.002)
Age if over 60 $\times \sigma_r$ [γ_7]	-0.0029 (0.0014)	-0.0035 (0.0017)	-0.0559 (0.0495)	-0.066 (0.059)
MSA x year dummies:	Yes	Yes	Yes	Yes
Household controls:	Yes	Yes	Yes	Yes
Sample:	Age >60	All	Age >60	All
Number of observations:	9,699	40,274	9,699	40,274
R-squared	0.1989	0.2526	0.1992	0.2550

Notes: Estimated coefficients are marginal effects from probit regressions estimated on 40,274 households in 44 MSAs in 1990 and 1999. The coefficients in brackets correspond to equation (4). The dependent variable takes the value of one if the household is a homeowner. All specifications include MSA x year dummies. Household controls include log household income, probability of not moving, and dummies for the head's occupation, race, education, and marital status. MSAs are deemed to have high rent variance if σ_r is above the 75th percentile household's value of 4.1 percent. All dollar values are in real (1990) dollars, deflated by the CPI less shelter.

Table 5: Net rent risk and the market rent-to-income ratio

	(1)	(2)	(3)	(4)	(5)	(6)
	Indicator variables for high rent variance, high probability of staying, and high market rent-to-income		Indicator variables for high market rent-to-income and continuous rent variance and probability of staying		Continuous variables	
Probability of staying (N) [ρ_4]	0.011 (0.011)	0.018 (0.012)	0.436 (0.084)	0.503 (0.090)	0.498 (0.086)	0.562 (0.099)
Market Rent / Household Income (r/Y) [ρ_2]	-0.035 (0.015)	-0.018 (0.016)	-0.034 (0.056)	0.202 (0.109)	0.217 (0.058)	0.377 (0.135)
Standard deviation of real rent x market rent/income ($\sigma_r \times r/Y$) [ρ_3]	0.010 (0.013)	-0.021 (0.020)	0.170 (0.515)	-7.849 (3.766)	0.710 (0.558)	-4.565 (4.075)
P(STAYS) x market rent/income ($N \times r/Y$) [ρ_5]	0.044 (0.013)	0.017 (0.019)	0.026 (0.060)	-0.267 (0.148)	-0.154 (0.063)	-0.343 (0.157)
P(STAYS) x standard deviation of real rent ($N \times \sigma_r$) [ρ_6]	0.032 (0.011)	0.018 (0.013)	6.761 (1.822)	4.643 (2.064)	6.470 (1.805)	4.377 (2.408)
P(STAYS) x s.d. of real rent x market rent/income ($N \times \sigma_r \times r/Y$) [ρ_7]		0.054 (0.025)		9.433 (4.381)		6.264 (4.788)
Pseudo R-squared	0.2565	0.2566	0.2585	0.2586	0.2598	0.2599

Notes: Estimated coefficients are marginal effects from probit regressions of equation (5) estimated on 39,468 households in 44 MSAs in 1990 and 1999. Out of the original sample of 40,274 households, the observations with the one percent highest and lowest values of market average rent/income r/Y are excluded from the regression. The dependent variable takes the value of one if the household is a homeowner. All specifications include MSA x year dummies and a full set of household controls including log household income and dummies for the head's occupation, age, race, education, and marital status. MSAs are deemed to have high rent variance if σ_r is above the median household's value of 2.7 percent. The probability of staying is high if the household is above the median probability of 88 percent. All dollar values are in real (1990) dollars, deflated by the CPI less shelter.

Table 6: The effect of net rent risk on the price-to-rent ratio

	(1)	(2)	(3)
Standard deviation of real rent (σ_r)	34.52 (11.88)	11.04 (5.55)	10.10 (3.81)
Real rent growth	68.99 (14.68)	16.73 (4.67)	18.14 (5.23)
Controls for MSA fixed effects?	No	MSA dummies	First differences
Number of observations	396	396	352
R-squared	0.0486	0.9471	0.1609
A one standard deviation increase in σ_r leads to...	0.62 (0.21)	0.20 (0.10)	0.18 (0.07)

Notes: Dependent variable is the price-to-rent ratio. Estimation is by OLS, following equation (6). Standard errors in parentheses. Number of observations equals 44 MSAs per year over the 1990-1998 time period. All specifications include year dummies. σ_r and real growth rates are computed based on the previous (rolling) nine years. A one standard deviation increase in σ_r is 0.018 (from a mean of 0.031). The average price-to-rent ratio is 15.72.

Figure 1: Kernel-Smoothed Age Profile of Homeownership, by Rent Variance

