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Abstract

For most US households, labor income is the most important source of wealth and housing is the most important risky asset. A natural intuition is thus that households whose incomes covary relatively strongly with housing prices should own relatively little housing. Under plausible assumptions on preferences and distributions, this result holds theoretically. Empirically, I find a significant effect: among US households, a one standard deviation increase in income-house price covariance is associated with a decrease of approximately $7,500 in the value of owner occupied housing. This empirical result implies greater cognizance of the interaction between labor income and asset risk on the part of some households than suggested by most analyses of stock market behavior. The analysis also suggests that many homeowners enter financial markets in a riskier position than typically thought. The results bolster the intuitive appeal of proposals for market- or tax-based risk sharing in housing prices.

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1 Introduction

Households' imperfect ability to trade away risk associated with labor income and housing prices complicates standard portfolio analysis. For many households, housing is the largest element in the asset portfolio and future labor income is the most important component of wealth. Under these conditions, it is natural to think that risk averse households will use housing purchases to hedge income risk. This paper evaluates the intuitive notion that households whose incomes covary relatively strongly with housing prices will purchase relatively little housing. I consider reduced housing purchases both on the extensive own-rent margin and on the intensive margin of value conditional on ownership.

A parallel literature shows that, under some conditions, investment in stocks decreases in the covariance between stock returns and labor income.[1] Formal empirical studies of investor behavior provide mixed evidence on the effect of income-stock return covariance on portfolio choice.[2] The recently celebrated existence of large holdings of employer stock in retirement plans suggests (but of course does not prove) that a large fraction of investors fail to recognize the importance of income-return covariance to aggregate portfolio risk.

The existing theoretical examinations of how income-return covariance affects portfolio choice assume that investors choose how much stock to own, but do not own housing. My analysis starts from the opposite assumption, which I consider a much closer approximation of reality. Based on the 1998 Survey of Consumer Finances, Kennickel, Starr-McCluer and Surette (2000) estimate that 66 percent of US households owned their own home in 1997. By contrast, they find that only 56 percent did any form of saving and just 49 percent held any stock, directly or through mutual funds or retirement plans. Among homeowners, the

[1] Viceira (2001) shows this for CRRA investors facing jointly normal stock price and wage distributions. Davis and Willen (2000) provide a similar result for CARA investors.

[2] Heaton and Lucas (2000) show that in a panel of US investors, the fraction of wealth put into stocks decreases in the covariance between total income and stock market returns. However, their result appears to occur over a disproportionately old and high wealth sample and decomposing income into wage and entrepreneurial components, the estimated effect of labor income covariance is insignificant. Vissing-Jorgenson (2000) emphasizes her failure to reject the null hypothesis of no relationship between portfolio weight on stocks and correlation between income and stock market returns.

median home value was \$100,000, whereas the median value of equities among those holding equities was \$25,000.

For the large majority of households, consumption of housing and investment in housing are closely linked; ownership of rental housing is highly concentrated, so that renters typically own no housing and homeowners typically own as much housing as they consume. Thus, unlike stock purchases, housing purchases affect utility both through the budget constraint and through direct present and future consumption benefits. Future consumption of housing implies that house prices affect welfare through both the numerator and denominator of future real wealth, a point frequently lost in the housing literature.[3]

A few recent papers consider housing choice in the context of simultaneously uncertain housing prices and labor income. Lustig and van Nieuwerburgh (2002) and Piazzesi, Schneider and Tuzel (2003) discuss the macro consequences of housing risk. Campbell and Cocco (2001), Cocco (2000) and Yao and Zhang (2001) solve numerically for optimal lifetime mortgage and housing behavior. These papers estimate a single population covariance matrix for prices, labor income and interest rates (and zero-covariance stocks in the case of Yao and Zhang) and assume jointly normal distributions. By contrast, I confine the theoretical analysis to a two period setting, allow for population heterogeneity in the covariance between labor income and housing prices and describe analytically conditions under which housing purchases fall with covariance. The assumptions required seem quite reasonable, but the result does not follow directly from the primitive assumption of concave utility. Ortalo-Magne and Rady (2002) show the result on the extensive margin in a special case.

Empirically, the equation of primary empirical interest is a regression of the dollar value of housing owned (which takes on a value of zero for renters) on income-price covariance, expected growth and variance of income and prices, demographic controls, and dummy variables indicating industry (two-digit SIC code) and MSA. I also estimate separately the effect of covariance on the intensive margin of purchases conditional on owning, and on the probability of deciding to own rather than rent.

[3]Sinai and Souleles (2001) emphasize renters' implicit short position in future housing prices. Similarly, young homebuyers may expect to move on to a higher quality of housing, as in Ortalo-Magne and Rady (1998), so that their utility may be decreasing, rather than increasing in future prices.

Empirical evaluation of the relationship between income-price covariance and housing purchases requires data on housing investment, the joint distribution of income and prices, and variables plausibly correlated with both.[4] The standard approach to estimating the covariance between labor income and asset prices is to examine the co-movements between prices and the incomes of a panel or repeated cross section of households. I instead estimate the covariance between house prices within metropolitan areas and the mean wages paid by different industries in the same MSAs. I then impute these estimated covariances to a large cross section of households from the 1990 US Census. Thus, for example, I obtain separate covariance estimates for retail workers and construction workers in the Boston MSA, and separate covariance estimates for retail workers in Boston and retail workers in Detroit. This approach lets me estimate covariances with local housing prices, which is important given the heterogeneity in price movements across markets. Further, it is plausible that households form estimates of income-price covariance based not on their personal histories, but rather on the experience of the industry in which they work. The cost of my approach is that I miss job separations, geographic mobility and intraindustry differences in income movements.

Critical to the identification strategy is the ability simultaneously to control for MSA and SIC fixed effects. In particular, MSA fixed effects subsume the current level and future distribution of housing prices. Variation within industries is helpful, too; while real estate brokers have incomes highly correlated with house prices, we would hardly expect them to own less housing than workers with similar characteristics in different industries. It is more plausible that the difference between the housing ownership of brokers and that of other workers is smaller in markets where incomes in other industries are more closely correlated with prices than in markets where incomes in other industries are far less correlated with prices than are brokers' incomes.

The second section of this paper presents a model of housing choice with uninsurable labor income and uncertain housing prices and lays out sufficient conditions for the result of decreasing housing purchases with increasing income-price covariance. The third section

[4] I use "price" to refer to the price of housing unless otherwise noted For empirical purposes, I use real housing prices and labor income, deflated by the US Consumer Price Index for non-housing goods.

details the panel data on wages and prices and the cross-sectional microdata on housing investment I use to estimate the effect of covariance on the value of housing owned. As expected, I find generally positive covariances, with correlations larger in the "right" industries and places, such as real estate brokerage nationally and amusement in Orlando. In the fourth section, I present regression results. The estimated effect of covariance on housing owned is significantly negative, and using instrumental variables to overcome measurement error increases the estimated magnitude dramatically. Combining effects on both the extensive and intensive margins, I find that a one standard deviation increase in income-price covariance is on average associated with a reduction in the value of housing owned of approximately $7,500. Most of this effect appears to be driven by reduced housing quantity conditional on purchase. The fifth section concludes with a discussion of the consequences of the results for our understanding of households' financial risk, their awareness of this risk and the potential gains to households from public and private sector mechanisms to offset housing risk proposed by Berkovec and Fullerton (1992), Shiller (1993) and Caplin, Chan, Freeman and Tracy (1997).

2 Housing Choice with Stochastic Labor Income and Prices

2.1 A Two Period Model: Key Features

Present housing decisions affect lifetime utility directly through the benefits of consuming more or less housing, and indirectly through the lifetime budget constraint. I assume that housing investment and consumption are non-separable in that renters' housing consumption is free to vary, but investment must equal zero; for owners, the quantity of housing owned must equal the quantity of housing consumed.[5]

[5] These constraints can be relaxed through direct or indirect ownership of rental real estate. However, the fraction of working aged households who own rental real estate either directly or through Real Estate Investment Trust shares is small, and the fraction of renters owning such assets is particularly small. Indirect real estate ownership through pension funds is presumably more widespread, but the exposure to local price

The effect of housing investment on the budget constraint depends on both present and future housing prices. Purchasing housing involves the sacrifice at the time of purchase of a combination of debt and equity in the amount of the (hedonic) quantity purchased times the present (hedonic) price, HP_1. Whenever the house is resold, "period 2," absent transaction costs, period 1's housing investment yields HP_2.

The date of resale is generally uncertain to homebuyers at the time of purchase.[6] Presumably, in considering expected resale value and the riskiness of resale income, homeowners weight the distribution of prices in each future state by the probability that sale will occur at that time. Rather than imposing a probability distribution of moves over multiple horizons, I will assume that all homeowners know for certain that they will resell at a future date which is fixed before housing purchases are made. In reality, habit formation and transaction costs presumably endogenize the date of resale to the housing choice problem.[7]

As discussed above, housing generally swamps non-housing investment in portfolios. This justifies the simplification that no other risky assets are available. Naturally, I allow homeowners to take on mortgage debt. I assume that mortgage debt is riskless both in the sense that the interest rate is deterministic and in that default is not possible. With unrestricted mortgage choice, households choose separately how much housing to purchase and how much of the other good to consume in the present. This is only an approximation to reality: mortgage rates are typically lower than consumer loan rates, and households may be constrained by a debt-equity ratio.[8]

I do not incorporate government policy into the analysis as US households are almost universally able to avoid capital gains taxes on housing. The progressivity of taxes and social

risk likely small in most cases.

[6] Venti and Wise (2000) show that older households appear generally to cash out only when severe financial shocks such as the need for long term healthcare arise.

[7] For example, a household purchasing a three-bedroom house today may find it more inconvenient and psychologically difficult to move to a one-bedroom apartment in retirement than would a similar couple purchasing a two-bedroom apartment today. However, the former couple might find the adjustment more worth the trouble.

[8] Alternatively, Laibson, Repetto and Tobacman (2000) suggest that households may use housing purchases as a device to force themselves to save.

insurance programs attenuate income risk, so income should be thought of as after tax and transfers. The deductibility of mortgage interest realistically creates heterogeneity in what I assume to be a uniform borrowing rate.

These assumptions allow us to confine the analysis to a two-period setting similar to that modeled by Henderson and Ioannides (1983). In period 1 households earn labor income and purchase or rent housing. For households choosing to purchase, there is a simultaneous decision of how large of a mortgage M to take on. Conditional on owning, the difference between first period income and the equity put into the home ($y_1 + M - HP_1$) goes to consumption of a composite non-housing numeraire good. While utility is defined over housing and numeraire consumption, more intuitive analytical results can be described if choice is considered to occur over housing and mortgage debt, with numeraire consumption implicit. Renters' first period numeraire consumption is equal to first period income less rental payments. Allowing renters to borrow or lend a riskless asset would not affect the analysis.

Period 2 represents the date of both homeowner resale and lease expiration for renters. At this time, households earn stochastic labor income, pay the principal and interest R on any mortgage taken on in the first period, take in the value of their home and allocate wealth optimally between housing and the numeraire good. This gives rise to indirect utility v.[9] From a first period perspective, utility over first period housing and numeraire consumption are deterministic, but future indirect utility is stochastic, depending on the realization of period two income and housing prices.[10] I assume that first period housing decisions do not affect the realization of second period income, ignoring any psychological consequences of homeownership not captured in the utility function.

[9] This leaves open the frequently observed (if puzzling) outcome that households never sell their homes. Because I have not included transaction costs, a non-sale corresponds to purchase and resale of the same quantity of housing.

[10] The chief cost of such a two period description relative to a many period model is that I am assuming a resolution of uncertainty upon resale. Incorporating continuing uncertainty might change the effect of prices on indirect utility, but the potential for added insight strikes me as small relative to the cost in complexity. Realistically, renters' and homeowners' investment horizons are different; lease expiration is typically one year, whereas homeowners rarely sell so quickly. I take this issue up in the empirical section below.

Second period housing prices enter indirect utility v in two ways. First, P_2 multiplies first period housing purchases in wealth. Second, the real price of housing is a bad to the extent that the household continues to consume housing. If housing is left as a bequest, P_2 clearly has both effects on heirs. I assume that P_2 is a sufficient statistic for the present value of rent per unit of housing to be paid by households choosing to rent housing in period 2.

I assume that no individual's demand affects housing prices, so that present and future prices are taken as exogenous. Although with imperfectly elastic housing supply, we would expect positive correlations between income and prices on average, as a matter of interpretation it should be emphasized that covariances are not restricted to be positive, nor need they be destructive of welfare. Indeed, renters may benefit from positive real income-price correlations and homeowners from negative correlations. This may partially explain the persistent home ownership of the elderly observed by Venti and Wise (2000) and Sinai and Souleles (2001).

In period one, households calculate expected lifetime utility under optimal behavior conditional on renting and on owning and choose the regime with the greater expected level. I consider first the utility maximization problem conditional on deciding to purchase a home. The objects of interest here are the effects of an increase in income-price covariance $Cov(P, y)$ on optimal housing purchases H and on expected utility conditional on owning. I consider expected utility conditional on renting later.

In the analysis below, I focus on covariance since the interaction of income-price correlation with variances is likely to matter for housing demand. One might be concerned that variances rather than comovement would then drive empirical results. I eliminate this concern in two ways. First, I instrument for covariance with correlation. Second, the estimated levels of variance are included directly or through MSA fixed effects in regressions. In the following model I assume that all other relevant moments are held fixed when covariance increases.

2.2 Homeowner Utility Maximization

Combining the assumptions above with intertemporal additivity of utility, conditional on deciding to own, expected utility is given by:

$$U(H, M, \Theta, Z) = u(y_1 + M - HP_1, H, Z) + Ev(W_2, P_2, Z|\Theta) \quad (1)$$

u is a concave utility function of first period numeraire and housing consumption. v is an indirect utility function, concave and increasing in second period numeraire wealth, W_2, and nonincreasing in second period relative housing price P_2. Z denotes household characteristics that shape preferences, and Θ is the set of relevant moments of the joint distribution of period two income and housing prices.

Defining the mortgage rate as R, second period wealth is:

$$W_2|_{own} = y_2 + HP_2 - RM. \quad (2)$$

The concavity assumptions imply that expected utility is maximized when housing purchases and mortgage debt satisfy the first order conditions:

$$0 = U_H = -P_1u_1 + u_2 + E(P_2v_1), \quad (3)$$

$$0 = U_M = u_1 - REv_1. \quad (4)$$

2.2.1 Effect of increasing covariance on conditional housing purchases

Expected second period utility will, in general, depend on all the moments of the joint distribution of future housing prices and income. If we consider a change in a particular parameter of the joint distribution θ, holding characteristics Z and the rest of the moments Θ constant, then we can think of the other moments as fixed parameters of the utility function. We can thus rewrite expected utility (1) conditional on Z and all of Θ except for θ as

$$U(H, M, \theta).$$

Noting the optimality conditions:

$$0 = U_{HM}dM + U_{HH}dH,$$

$$0 = U_{HM}dH + U_{MM}dM,$$

total differentiation of the first order conditions (3) and (4) gives us two equations in two unknowns, which can be solved jointly for the change in optimal housing purchases associated with a small increase in the parameter θ. These total derivatives are given by:

$$0 = U_{M\theta} + U_{MM}\frac{dM}{d\theta} + U_{MH}\frac{dH}{d\theta}, \tag{5}$$

$$0 = U_{H\theta} + U_{HM}\frac{dM}{d\theta} + U_{HH}\frac{dH}{d\theta}. \tag{6}$$

Combining and rearranging conditions (5) and (6) gives the result:

$$\frac{dH}{d\theta}(U_{MM}U_{HH} - U_{MH}^2) = -U_{H\theta}U_{MM} + U_{MH}U_{M\theta} \tag{7}$$

The term multiplying the derivative of interest $\frac{dH}{d\theta}$ must be positive by concavity of u and v (see, for example, Mas-Collel, Whinston and Green (1995), Appendix D). The second derivative U_{MM} similarly must be negative, so dividing equation (7) by $-U_{MM}$ we have the relation:

$$\text{sign}(\frac{dH}{d\theta}) = \text{sign}(U_{H\theta} - \frac{U_{MH}}{U_{MM}}U_{M\theta}). \tag{8}$$

Intuitively, a parameter shift tends to reduce the quantity of housing if the shift reduces the marginal benefit of housing purchases. This effect is modified by changes in mortgage debt if changes in housing investment affect the marginal benefit of mortgage debt. An induced increase (decrease) in the marginal benefit of mortgage debt tends to increase (decrease) housing purchases if increased housing investment makes mortgage debt relatively attractive. The opposite implications arise if mortgage debt becomes less attractive with housing purchase.

In our case, the distributional parameter of interest θ is the covariance between income and prices, $Cov(P, y)$. Equation (8) implies the following result:

Result 1 *Both of the following are sufficient conditions for housing purchases conditional on ownership to decrease in the covariance between labor income and housing prices, holding all other relevant moments of the joint distribution constant:*

1. *The second derivative* $U_{HCov(P,y)}$ *is negative and* $U_{MCov(P,y)}$ *is zero everywhere.*

2. $U_{HCov(P,y)}$ *and* $U_{MCov(P,y)}$ *are negative and* U_{HM} *is positive everywhere.*

2.2.2 Special Case: Additively Separable Mean Variance Indirect Utility

The first condition for housing purchases to decrease in covariance in Result 1 is satisfied under a pair of assumptions shared by Berkovec and Fullerton (1992) and Flavin and Yamashita (2001). These papers specialize the homeowners' maximization problem by assuming first that housing is purchased only once, so that expected indirect utility Ev in equation (1) depends only on the distribution of future wealth. The second assumption is that expected indirect utility depends only and additively on the mean and variance of second period wealth:

$$Ev = a(EW_2) + b(Var(W_2));$$

$$a' > 0, b' < 0.$$

With wealth given by (2), and the borrowing rate R fixed between purchase and sale of housing, the variance of future wealth is given by:

$$Var(W_2) = Var(y_2) + 2HCov(P,y) + H^2Var(P_2). \tag{9}$$

In this case, an increase in covariance (holding expected income and prices constant) has no direct effect on the first period utility or on the value of expected second period wealth. Equation (8) thus reduces to:

$$\text{sign}(\frac{dH}{dCov(P,y)}) = \text{sign}(b'\frac{\partial^2 Var(W_2)}{\partial H \partial Cov(P,y)}) = \text{sign}(2b') < 0.$$

Hence, in this setting, optimal housing purchases conditional on owning are decreasing in covariance, matching intuition. We can also see that for constant variance and mean growth in income and prices, for any positive level of housing, the variance of wealth is increasing in the covariance term. Thus, expected utility falls for any level of housing. By implication, expected utility conditional on owning must fall.

Both mean-variance utility and the absence of future housing purchases are highly restrictive assumptions. Normality of prices and income are rejected empirically. Quadratic utility, required to guarantee mean variance preferences absent knowledge of the distribution of wealth[11] implies counterintuitively increasing absolute risk aversion. More importantly, indirect utility will take the price of housing as a separate argument unless homeowners are certain that when they dispose of their home, they and the heirs they care about will be dead or in a place with uncorrelated housing prices. Nevertheless, to the extent that we believe homeowners are in a long position in housing and that mean-variance utility is a decent approximation, the intuitive result stands.

2.2.3 General Indirect Utility

Without the mean-variance and no future purchase of housing assumptions, an increase in the covariance between income and prices will affect the net marginal benefit of both housing and mortgage debt by changing the riskiness of future real wealth. To obtain a clear prediction on the effect on housing purchases, we must appeal to the second condition of Result 1. That is, we need to show that the marginal benefit of housing is decreasing in covariance, that the marginal benefit of housing is not decreasing in mortgage debt and that the marginal benefit of mortgage debt falls with increasing covariance.

Using the first order conditions (3) and (4), noting that a small change in income-price covariance has no effect on first period utility evaluated at a particular optimal choice of H and M and using properties of expectations, we obtain:

$$U_{HCov(P,y)} = EP_2 \frac{\partial Ev_1}{\partial Cov(P,y)} + \frac{\partial Cov(P_2, v_1)}{\partial Cov(P,y)}, \tag{10}$$

$$U_{MH} = u_{12} - P_1 u_{11} - RE(P_2 v_{11}), \tag{11}$$

$$U_{MCov(P,y)} = -R \frac{\partial Ev_1}{\partial Cov(P,y)}. \tag{12}$$

[11]see Rothschild and Stiglitz (1970).

To a first order, the effect of an increase in income-price covariance $Cov(P, y)$ on the covariance between price and marginal utility of wealth, the second term on the right hand side of (10), is equal to the second derivative of indirect utility with respect to wealth, v_{11}.[12] By concavity, this term is negative. This effect is intuitive; marginal utility is decreasing in labor income, so if prices are high when income is high, larger realizations of price are associated with smaller realizations of income.

The effect of a change in income-price covariance on the product of expected housing prices and expected marginal utility $E(P_2 v_1)$ is more difficult to sign.[13] Expected marginal utility is typically judged to be increasing in risk[14], so we can infer that the effect of income-price covariance on expected marginal utility will be positive if increasing covariance increases risk. Absent future housing purchases, an increase in covariance, conditional on positive housing purchases implies increased variance (and presumably increased risk[15]) of future

[12]To see this result, define a vector valued function of price and income, conditional on first period decisions and parameters as follows:

$$X = \begin{bmatrix} P_2 \\ y_2 \end{bmatrix}, F(X) = \begin{bmatrix} P_2 \\ v_1(y_2 - MR + P_2 H, P_2) \end{bmatrix}.$$

To a first order approximation,

$$\begin{bmatrix} Var(P_2) & Cov(P_2, v_1) \\ Cov(P_2, v_1) & Var(v_1) \end{bmatrix} \approx \begin{bmatrix} \frac{\partial P_2}{\partial P_2} & \frac{\partial P_2}{\partial y_2} \\ \frac{\partial v_1}{\partial P_2} & \frac{\partial v_1}{\partial y_2} \end{bmatrix} \begin{bmatrix} \sigma_h^2 & Cov(P, y) \\ Cov(P, y) & \sigma_y^2 \end{bmatrix} \begin{bmatrix} \frac{\partial P_2}{\partial P_2} & \frac{\partial v_1}{\partial P_2} \\ \frac{\partial P_2}{\partial y_2} & \frac{\partial v_1}{\partial y_2} \end{bmatrix};$$

so

$$Cov(P_2, v_1) \approx \frac{\partial v_1}{\partial P_2}\sigma_h^2 + \frac{\partial v_1}{\partial y_2} Cov(P, y).$$

[13]One might consider that differences in covariance are generated by purely idiosyncratic shocks to income and housing prices, uncorrelated with the underlying distribution, so that covariance increases through the covariance in the idiosyncratic shocks. In this case, a Taylor expansion of marginal utility would show no first order effect of an increase in covariance, and a second order effect proportional to the expectation over the distribution of price and income shocks of $Hv_{111} + v_{112}$. This is qualitatively the same result as discussed in the text. More likely, differences across groups in covariances arise from differences in income and prices that are correlated with the existing distributions, calling a Taylor expansion approach into question.

[14]This is a precondition for precautionary savings. Venti and Wise (2000) present evidence suggestive of precautionary motives with respect to home equity among the elderly.

[15]Without knowing the distribution of income and price shocks, we cannot be certain that an increase in

consumption, as noted above. However, non-housing consumption decreases with housing prices if households become net purchasers of housing in the future (either through purchase of a higher quality home or a sufficiently long planned stay in sufficiently high quality rental housing). In this event, with additive separability in utility between housing and other consumption, an increase in income-price covariance acts to smooth marginal utility, thereby acting as a form of insurance. In the likely case that households trade up in quality in some cases, and down in others, or with strong complementarities between the two forms of consumption, the effect of covariance on risk becomes yet more difficult to evaluate.

Thus, an increase in income-price covariance has a first order negative effect on the benefit of purchasing housing by decreasing the covariance between expected prices and marginal utility. Precautionary saving motives work in the opposite direction for homeowners that can be considered to have a long position in local housing prices. A negative sign on the term $U_{HCov(P,y)}$ hence seems probable, but cannot be deduced from concavity alone.

Inspection of equation (12) reveals that the term U_{HM} is positive unless u features very large negative cross-consumption effects. By concavity, $-P_1 u_{11}$ is positive. Similarly, since second period prices are never negative and v_{11} is everywhere negative, the term reflecting the cross effect on second period wealth $-RE(P_2 v_{11})$ must be positive.

The term $R\frac{\partial EV_1}{\partial Cov(P,y)}$, the negative of the cross partial $U_{MCov(P,y)}$, reflects precautionary motives. Again, for homeowners certainly in a long position in housing, this term is most likely positive and $U_{MCov(P,y)}$ thus negative, if marginal utility is convex.

Summarizing, the second sufficient set of conditions in Result 1 for housing purchases to decrease monotonically in income-price covariance, conditional on ownership, seem likely to be met but require some assumptions on the parameters and functional form of both utility and the income and price distributions to be certain. In particular, with large expected future housing needs, increasing covariance may act as a form of insurance, so that expected utility conditional on owning may be increasing. In this case, however, renters presumably benefit even more from positive covariance since they most likely hold a relatively shorter position in housing prices. Hence homeownership most likely remains relatively unattractive

variance increases risk, as emphasized in Rothschild and Stiglitz (1970).

as income-price covariance rises.

2.3 Renters' Expected Utility

At the end of a lease (typically one year, but frequently less - see US Census Bureau (1995)), renters may either rent housing again or purchase a home. In either event, upon lease termination, present renters will have to pay for local housing services for the remainder of their stay in the same housing market. I assume that the price of housing upon lease termination is a sufficient statistic for the present value of these payments.[16] Renters' utility is thus given by:

$$EU = u(y_1 - H \times Rent_1, H, Z, \Theta) + Ev(y_2, P_2, Z|\Theta),$$

It is natural to assume that renters' utility increases in the covariance between income and prices. When prices are high renters face diminished utility; they presumably value income relatively more in such states of nature. This intuition works most clearly with the additive mean variance utility over numeraire consumption discussed above, and with second period housing needs fixed at some level $\bar{H}$ and hence irrelevant to the maximization. Renters' second period wealth then has mean and variance given by:

$$EW_2 = Ey_2 - \bar{H}EP_2$$

$$Var(W_2) = Var(y_2) - 2\bar{H}Cov(P, y) + \bar{H}^2Var(P_2).$$

In this case, the mean of second period wealth is not changed by an increase in covariance, but variance of wealth falls. Hence, renting is relatively more attractive with an increase in covariance.

Fixed future housing needs are a peculiar assumption in the context of housing choice. The fact that renters may substitute away from housing in high price future states lessens the insurance value of renting. For example, with additive log utility over consumption and housing, covariance between income and prices can be shown to have no effect on expected

[16] Empirically, I find a high correlation between (i) the covariance between income and prices and (ii) the covariance between income and rents.

utility conditional on renting, holding the rest of the income-price distribution constant.[17] However, with such preferences utility conditional on ownership most likely falls, since real wealth presumably becomes riskier with increasing covariance between labor income and housing resale income. The important and plausible condition is that expected utility conditional on renting increases monotonically in covariance relative to expected utility conditional on owning.

3 Empirical Estimation of the Effect of Income-Price Covariance on Housing Demand

3.1 Equations to be estimated

The theoretical discussion suggests that we should observe empirically a relationship between covariance and housing purchases as depicted in Figure 1. The covariance between income and prices, Cov(P,y) is measured on the horizontal axis. Optimal housing purchases conditional on covariance (H*, represented by the thick line) and maximized utility conditional on owning (U|Own) or renting (U|Rent) are measured vertically. Housing purchases are shown to decrease in covariance (the intensive margin) to a critical level Cov*, above which a combination of the risk conditional on owning and the low consumption of housing implies greater expected utility conditional on renting (the extensive margin). Naturally, such a relationship will be conditional on covariates. This pattern of homeownership appears quite plausible theoretically, but because the results are not unambiguous, we cannot interpret an empirical test of the model as a test of rational investor behavior. Rather, we are jointly testing that the model presented has some application to risk as perceived by households

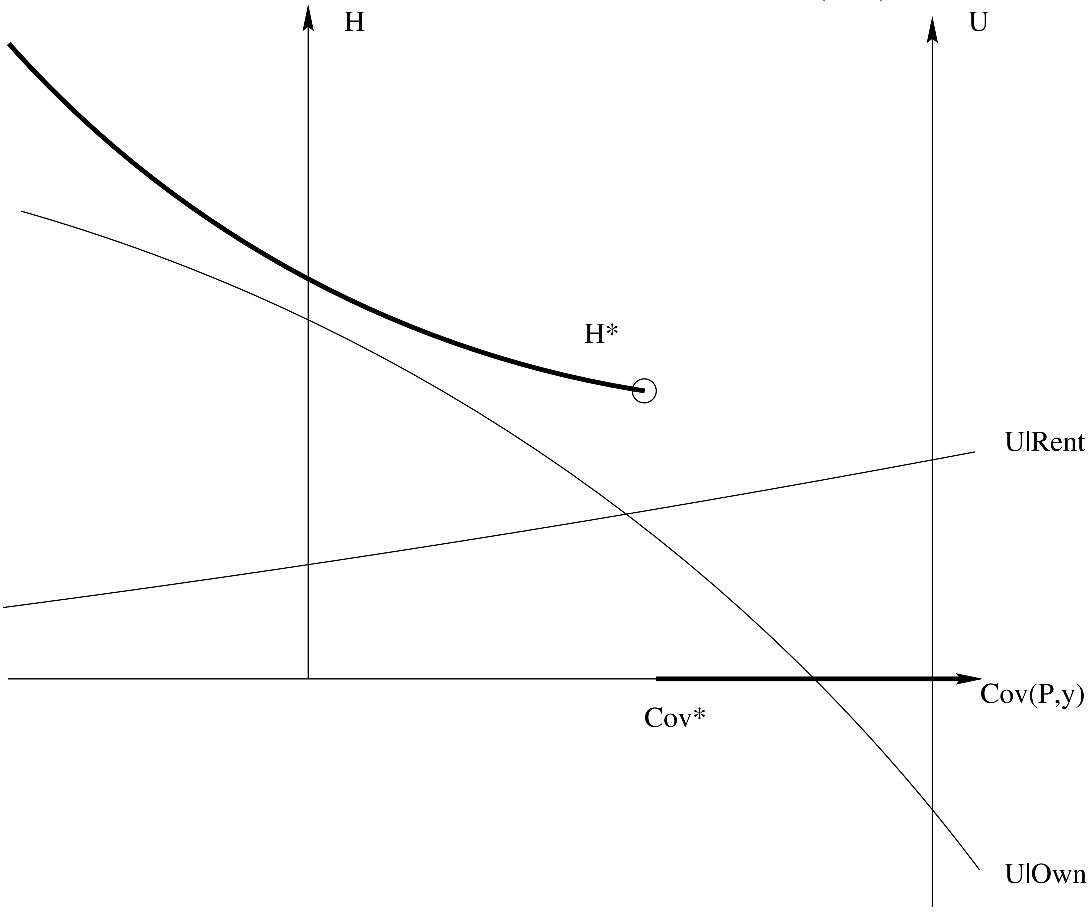
[17] In this case, expected utility conditional on renting is

$$\log(y_1 - H_1 \times Rent) + \log(H_1) + E(log(y_2 - H_2P_2) + log(H_2)).$$

This implies constant expenditures on housing and expected second period utility is $E(log(y_2) - log(P_2)) - 2log(2)$, which does not change with covariance. It is interesting to note that households are risk seeking in the price level, and risk neutral with respect to log prices in this case.

and that households act on this risk.

Figure 1: Effect of labor income - price covariance $Cov(P, y)$ on housing purchases



Such a figure suggests estimation of the effects of increasing covariance on the extensive margin, the intensive margin, and the combined effect on both margins:

$$RENTER = F(Cov(P, y), Z, \epsilon), \tag{13}$$

$$VALUE|OWN = b_0 + b_1 Cov(P, y) + Zb_2 + \epsilon, \tag{14}$$

$$VALUE = \beta_0 + \beta_1 Cov(P, y) + Z\beta_2 + \epsilon. \tag{15}$$

Here Z is a set of observable characteristics potentially correlated with demand for housing consumption or investment, $Cov(P, y)$ is the covariance between income and price levels, $RENTER$ indicates renting housing and ϵ represents idiosyncratic household tastes for housing consumption and investment. In equation (15), VALUE is a variable which takes on the value of a household's home if it is owner-occupied, or zero if the household rents. In the conditional regression (14), VALUE|OWN is the value of a homeowner's house.

There are several plausible ways to estimate equations (13) through (15). It is not obvious what the right hand variable of interest should be. Holding the variance of prices and income constant, the theory laid out in section 2 implies that housing purchases should fall both in the covariance between income and housing prices and in the correlation $Corr(P, y) = \frac{Cov(P,y)}{\sqrt{Var(P)Var(y)}}$. In some specifications I create an instrument for covariance that uses correlations.

Estimating the effect of covariance on the extensive margin of value of housing conditional on purchase, equation (14), involves a problem of selection. If the probability of renting rises in covariance then, conditional on covariates Z, households with relatively large income-price covariance values who decide to purchase houses presumably have an unobservably large taste for homeownership. This induces correlation between $Cov(P, y)$ and ϵ, biasing the estimated coefficient b_1 downward.[18] I thus focus attention on estimation of the effect of covariance on the extensive margin of renting or buying alone (equation (13)), and on the effect of covariance on the dollar value of housing owned, counting renters as owning zero housing as in equation (15).

Theoretically, both short and long term covariances should be considered as factors in housing purchases, as potential renters must consider the joint distribution of income and rents between lease signing and termination, typically one year. By contrast, homeowners have much smaller annual moving probabilities. However, since we do not know the actual horizon which homeowners use to consider risk, and because short and long term covariances are highly correlated, I will restrict myself to consideration of a single covariance. In particular, I select five years as a reasonably long horizon which does not sacrifice too many

[18] A Heckman-like sample selection approach is indicated, but requires either assumptions on the functional form of errors or an exogenous shifter of housing tenure choice uncorrelated with demand conditional on ownership. There is some debate as to whether such an instrument exists; I am inclined to believe it does not. Given the small effect found on the extensive margin, any such correction would be expected to have small consequences.

observations with limited panel price and income data.[19]

3.2 Estimating the income-price variance-covariance matrix

The covariance $Cov(P, y)$ must be estimated. To do so, I assume that percentage changes in labor income and housing prices are random walks with drift:[20]

$$\frac{y_t}{y_{t-5}} = g_y + \epsilon_{yt}$$

$$\frac{P_t}{P_{t-5}} = g_h + \epsilon_{ht}$$

$$E\epsilon_{it} = 0,\ i = y, h$$

$$E\epsilon_{it}^2 = \sigma_i^2,\ i = y, h$$

$$E\epsilon_{ht}\epsilon_{yt} = \sigma_{hy}.$$

$$E\epsilon_{yt}\epsilon_{yt-x} = E\epsilon_{ht}\epsilon_{ht-x} = E\epsilon_{yt}\epsilon_{ht-x} = 0;\ x \neq 0$$

Here, g_y and g_h are mean growth rates of income and housing prices and ϵ_{yt} and ϵ_{ht} are deviations from mean growth in year t.

The covariance between the level of income and prices between years t and t+5 is thus the product of period t income and price times the estimated covariance of percent (approximately log) changes. If we observed housing choice and income in period 1, we would calculate:

$$Cov(P, y) = y_1 P_1 \sigma_{hy},$$

$$Var(y) = y_1^2 \sigma_y^2.$$

The interaction of income and log change covariances and variances to create level covariance and variance measures is notationally unpleasant. This problem cannot be overcome

[19]Estimates based on one and three year horizons give results consistent with those reported below. The Chicago Title Company reports that approximately 55 percent of all homebuyers are repeat buyers.

[20]It is well known that there is some predictability in housing prices. I find some evidence for this in the data, but more involved functional forms would likely add noise to the error in covariance estimates. In earlier versions of this paper I purged income and prices of information from lagged changes and interest rates and found no substantial changes in results.

by estimating equations (13) through (15) in log form. The equation of primary focus (15) includes a dependent variable that takes on zero values, and covariance itself may be zero or negative. In the tables of results, I label $Cov(P, y)$ by COV(P,y) and σ_{hy} by COV(lnP,lny).

In the model, P_1 is an hedonic price and H represents hedonic quality. I assume a constant hedonic price within markets (and assign all SIC cells within an MSA the same price series for covariance calculations), so that an MSA fixed effect controls for P_1 and the distribution of P_2.[21] When the value of housing is measured as the dollar value of a house, the theory predicts a negative effect of covariance on value. While interpreting a negative coefficient on covariance as supportive of the model does not require such an assumption, for easier interpretation of results I assume a constant hedonic price of \$1 across MSAs.

With the assumption on hedonic prices, my estimate of the covariance between income and price levels is the product of income and the covariance of income and price shocks:

$$Co\hat{v}(P, y) = \hat{y}\hat{\sigma_{hy}}.$$

Similarly,

$$Va\hat{r}(P) = \hat{\sigma_P^2},$$

and

$$Va\hat{r}(y) = \hat{y^2}\hat{\sigma_y^2}.$$

In the regressions, I divide the variance of income by the income level so that all right hand side variables are in levels or in interactions with income. The correlation between income and house prices is estimated as:

$$\widehat{Corr(P, y)} = \frac{\widehat{Cov(P, y)}}{\sqrt{\widehat{Var(P)}\widehat{Var(y)}}}.$$

The standard approach to estimating household level income-return covariances is to compare asset price changes to changes in individual households' incomes, with household

[21] Of course the price of physical quantities such as square footage vary within markets, so proxying for H with an individual hedonic attribute would be a poor idea. When location is deemed a component of H, the assumption is much weaker. Estimating a different hedonic price for each MSA would ask too much of available data and would involve comparing relative value of locations in different markets

level data coming from panel or repeated cross sectional sources.[22] Instead, I use wage data by industry (2 digit SIC code) and region (MSA). This data comes from the Bureau of Labor Statistics' Covered Employment Series, and covers the years 1975 to 1999. This deviation from standard practice is motivated by two considerations. First, good quality, regionally disaggregated household income data is not readily available for long time series and housing price changes vary dramatically across regions,[23] rendering the covariance between income and national housing prices difficult to interpret. Second, it is not clear how individuals form expectations about the joint movements of their income and asset prices. It seems no less reasonable that they would consider the experience of the industry in which they work than that they would consider their personal earnings history. A similar argument is implicit in Davis and Willen (2000). I use mean wages rather than aggregate wages to avoid overstated changes in wage prospects in industries with small numbers of employees. I thus fail (arguably rightly) to observe zero wages for the unemployed within any MSA-SIC cell.

The effect of variance of log prices and income and the covariance term on the variance of lifetime wealth will depend on individuals' expected length of stay in their industry and MSA and the sensitivity of their own wages to industry shocks. There is no clear prediction on the relative effects across ages. Younger households may have longer expected stays in an industry but older, more senior, workers' pay may be more sensitive to industry performance.

To estimate housing price changes, I use the Office of Federal Housing Enterprise Oversight (OFHEO) repeat sales Conventional Mortgage Housing Price Index, which provides indices for 148 MSAs for the years 1975 to 2001.[24]

I deflate both income and house prices by the US consumer price index for all non-housing goods so that variances, covariances and growth rates are in real terms. Local price indices are available but less reliable than the national index. In this setting, I do not consider it

[22]As in Heaton and Lucas (2000), Vissing-Jorgenson (2000), Cocco (2000), Campbell and Cocco (2001).

[23]The housing price data reveals a range from 6 percent (in Bellingham, WA) to 34 percent (in Charleston, SC) in deviation of percentage change in CPI deflated housing prices from 1995 to 2000 relative to mean changes over the period 1976 to 2000.

[24]The repeat sale methodology is meant to yield an index of prices for units of comparable quality. Renovations and depreciation are not observed, and may bias the index.

appropriate to differentiate between economy-wide shocks and industry-specific wage shocks; this would be appropriate only if households held risk-minimizing positions in some regional index. I do, however, estimate the covariance between the wages of each MSA-SIC cell and nominal mortgage interest rates and percentage changes in the S&P index of stock prices. Both of these covariances are correlated with income-price covariance and could plausibly be correlated with housing decisions.

Defining covariance as the interaction of household head's income and an industry level covariance of log changes to mean income and house prices means that there is variation in this measure within MSA-SIC cells. Hence, regressions can be run not only with MSA-SIC fixed effects, but even with fixed effects at the cell level and income interactions with MSA and SIC dummy variables. An important consequence is that equilibrium market conditions and correlates of career choice are unlikely to bias results. An alternative specification, which allows fewer degrees of freedom, also follows from the analysis of section 2. In addition to the individual level analysis, I consider the effect of covariance or correlation between shocks to income and prices, not interacted with income. Such measures of comovement do not vary at the MSA-SIC cell level, and I hence conduct this analysis over cell means, with fixed effects for MSAs and SICs included. Cell level analysis is best suited to evaluation of the effect of covariance on the own-rent decision, where it is not clear that an income interaction is appropriate.

3.2.1 Variance-Covariance Results

Aggregate variance and covariance statistics are reported in Table 1. These statistics arise from a merge of the variance-covariance estimates with income, industry and MSA data from the 1990 US Census five percent state sample from Minnesota's IPUMS database. The census population I consider consists of household heads under age 62 with positive labor income, no retirement income and identifiable MSA and SIC categories for which time series data were available both from the OFHEO house price and BLS wage series. These limitations leave me with just over one million observations in approximately 7,400 MSA-SIC cells.[25]

The mean variance of log income growth (VAR(lny)) is approximately 1 percent, relative to mean growth (GROW(y)) of approximately 4 percent. Mean variance of housing prices (VAR(lnP)) is 4.9 percent, around a mean five year real growth GROW(P) of 4.7 percent. The mean log covariance (COV(lnP,lny)) is 0.6 percent, associated with a mean correlation CORR(P,y) of 0.29. There is considerable variation in the magnitude of covariance and approximately one quarter of household heads work in industries with negative income-price covariances. Measurement error presumably biases variance estimates upwards and correlation estimates downwards. The data thus suggest that the covariance between income and prices has an effect on risk of similar magnitude to the variation driven by idiosyncratic variation in income and prices.

Corr(S,y) is the covariance between stock market returns (from CRSP's value weighted index) and cell income divided by the variance of stock market returns. Notably, the stock correlation measure is on average positive and significantly different from zero (although standard errors are biased by serial correlation, a problem difficult to solve with a small number of observations). This stands in contrast to the results of Davis and Willen (2000). The failure of that paper to find significant occupation-stock market covariances may be due to small samples or short horizon (see Griliches and Hausman (1986)) estimation.

In stark contrast to the existing literature on housing and risk, I find similarly significant and typically positive correlations for stocks and housing prices CORR(S,P), with a mean of 0.21. The conventional view (as in Flavin and Yamashita (2001)) that stock returns and house price increases are uncorrelated may again be premised on noisy short horizon estimation. In entering the stock market, workers must thus consider not only background income and price risk and stock market risk, but also considerable covariance between existing sources of wealth and stock market returns.

The covariance between income and interest rates COV(R,lny) is negative on average and strongly negatively correlated with the covariance between income and stock market

[25] To avoid nearly singular matrices, I also eliminate industries which never have more than 200 observations in any MSA and MSAs with less than 200 observations.

returns.

The income-price correlation results for particular industries (SICs) and MSA-SIC cells largely accord with intuition. The largest income price correlation at the national level (taking averages over regional cells' covariances with regional prices) belongs to the real estate industry, with a mean correlation of 0.61. Other large correlation industries are auto repair services and parking; automotive dealers; engineering, accounting research, management and related services; and building construction general contractors. Nationally, no industries have negative mean covariances.

The MSA-SIC cell that partly inspired this study, stock brokers in New York City, have the relatively large correlation of 0.44. Amusement and recreational workers in Orlando also have a predictably large correlation at 0.64. Auto workers (under the larger heading of transportation equipment industry workers) in Detroit have a correlation of 0.18, which is small relative to the overall national mean and relative to the Detroit MSA mean of 0.49 but large relative to the national transportation equipment industry mean of 0.12. Similar statistics apply to the petroleum industry in Houston.

3.3 Cross Sectional Homeownership and Demographics Data

The IPUMS Census microdata includes variables describing household heads' wage income, age, sex, race, family size and education. These variables are summarized in Table 1.

RENTER is a variable that indicates renting rather than homeownership; approximately 63 percent of the sampled household heads are homeowners. The variable VALUE, introduced above, is equal to the dollar value of owned housing, or zero for renters. Because this variable includes zeros for renters, there are more observations and a much lower mean than the conditional VALUE|OWN, which is the dollar value of housing for owner-occupiers only.

While the level of asset wealth is not identified in the Census, total investment income is. Table 2, drawn from a smaller IPUMS sample, suggests that the assumption that only housing and debt are held is not a bad approximation for the households in question, although it must be noted that Kennickel et al. (2000) show that a majority of stock ownership is in the form of retirement plans. The almost complete absence of asset income among renters is particularly striking and suggests that housing is, indeed, the dominant asset for US households. While approximately two-thirds of households own housing, less than one-third have any investment income. Mean investment income is approximately two percent of mean home value among owners and accounts for approximately one and one-half mean month's rent for renters. Investment income is highly skewed in the population, median investment income is just \$30 for owners and zero for renters. There is some evidence of precautionary savings in the sample population; an unreported regression of investment income on characteristics and on industry variance of mean wages yields a significant and positive relationship.

3.4 Identification and Inference

In a regression of the form (15):

$$VALUE = \beta_0 + \beta_1 Cov(P, y) + Z\beta_2 + \epsilon,$$

a natural concern that the covariance between income and prices may be correlated with other housing demand factors. I control directly for the variables commonly thought to influence housing consumption and investment decisions described above and summarized in Table 1 and for dummies indicating marital status, both directly and interacted with income. These are similar to the regressors used in Ioannides and Rosenthal (1994), for example, but I include income interactions and exclude some within-MSA geographic controls which are likely endogenous.

Naturally, the price level and the moments of changes in price must be included in Z. I do so by controlling for MSA-SIC cell fixed effects; all members of a particular cell share the same price level and future distribution, so there is no residual variation in price in ϵ. There is variation in $Cov(P, y)$ within cells because the log covariance is interacted with income. I thus also interact MSA fixed effects with income. This suffices because covariances are established using a single price series for each MSA. Income variance and income-price covariance levels are not collinear with cell dummy variables nor with MSA or SIC interactions with income. I control directly for the estimated variance of income and for the estimated covariance of income with bond and stock returns.

Some of the effect of income-price covariance on housing investment may stem from correlation with unobserved higher moments of the joint distribution. Such concerns can be allayed somewhat by instrumenting for covariance with the interaction of income and the correlation between income and prices, which removes the scaling by variances. This instrumental variables approach is also attractive given that covariance measures can be expected to have more severe outlier problems than the bounded correlation measure. Income-price covariance may also be correlated with the covariance between wages and mortgage rates or stock market returns discussed above, in that all of these variables indicate cyclical earnings. I directly control for estimated wage covariances with stock returns and contemporaneous 30 year fixed mortgage rates.

We might be concerned about selection in that households who wish to purchase a large quantity of housing might choose occupations with low wage-price covariances with portfolio considerations in mind. However, either direction of causality is consistent with household-level belief that increasing covariance increases homeowners' exposure to risk and action upon that belief. These are the objects of present interest.

Measurement error presents another challenge. Income and cell level covariance of log income and price shocks are estimated with both conceptual and observational error. Conceptual error arises in income because Census reported income is not equal to income in the year of housing purchase. Observationally, reported income is known to be a noisy measure of present income.[26]

There is considerable conceptual error in the covariance estimates when applied to household heads. Individuals' income changes do not track industry mean wage changes both because of occupational mobility and because of different wage structures within industries. In general, this conceptual error cannot be considered noise with a mean of zero. Coefficient estimates must be taken as the effect of industry level covariance, rather than true covariance on individual housing choice. Thus, even if we assumed a utility function, recovering any

[26] See, for example, Bound and Krueger (1991). There is also spousal income to consider - alternative specifications with covariances calculated as within-household weighted averages yield similar results, but cloud the interpretation of cell or SIC fixed effects.

underlying parameters would require a model of how individual income is linked to industry mean wages. Also, estimating covariances for all households based on the period 1975 to 1999 misses the fact that different covariances will apply to different households depending on the year of their purchase and their resale horizon. It is encouraging in this regard that covariances estimated in the first half of the time series are highly correlated with covariances using the second half. Finally, household heads' labor may not be the dominant source of some households' income.

Observationally, the log income-price shock covariance σ_{hy} is measured with significant error. I estimate a mean standard error of the covariance estimates of 0.02, considerably greater than the mean estimate of covariance of 0.006. The mean ratio of the absolute value of covariance to the standard deviation of the estimate is just 0.36. A particular source of concern is outliers. While 98 percent of observations have estimated σ_{hy} values less than 0.025, the maximal value is approximately 10 times this amount in magnitude and the minimal value three times.

Deletion of outliers will not undo the problems of observational measurement error. A more promising approach is to use alternative measures of covariance as instruments. In general, if we can find a $y\sigma_{hy}$ interaction measured with error orthogonal to that in the base estimate, then the IV estimate will not suffer from observational attenuation bias. Abstracting from measurement error in income, spatial correlation among income-price correlations provides the basis for such an instrument. Intuitively, one expects some similarity in industry structure across regions, motivating this choice of instrument. Controlling for covariates and fixed effects, I find that the interaction of income and mean income-price correlation among the ten "nearest neighbors" of a particular MSA-SIC cell is significantly positively correlated with individuals' estimated level covariance.

More precisely, for an individual i working in industry s in MSA m and earning y_i, with covariance $y_i\sigma_{h_m y_{sm}}$, I use the instrument

$$\tilde{Cov}(P_m, y_{ism}) = y_i \bar{Corr}(P_{n_m}, y_{sn_m}), \tag{16}$$

where $\bar{Cov}(P_{n_m}, y_{sn_m})$ is the mean covariance between log income and house prices for workers in the same SIC code, working in the ten MSAs n_m closest to MSA m. For example, the correlation between income of stockbrokers in Sacramento and housing prices in Sacramento forms part of the instrument for the covariance between the income of stockbrokers in San Francisco and housing prices in San Francisco. These instruments have the "second stage" attraction that measurement error in incomes and prices in one MSA should arise from sources orthogonal to sources of error inn a neighboring MSA.[27]

To get an idea of the importance of the IV approach, regressing the correlation between income and house prices on the same correlation for the nearest neighboring MSA yields a coefficient of .30. If the neighbor's correlation is instrumented for by the correlations of the fifth closest MSA, a coefficient indistinguishable from 1.0 is obtained, implying a reliability ratio of approximatel $\frac{1}{3}$. Interaction with income and variances renders the implied reliability ratio still smaller for $Cov(P, y)$ to approximately $\frac{1}{4}$.

4 Results

4.1 Effect of Covariance on Housing Purchases Combining the Extensive and Intensive Margins

The object of primary interest is the effect of income-price covariance COV(P,y) on the value of housing owned VALUE. The additional right hand side control variables labeled Z in equation (15) are the demographic and variance-covariance variables discussed above and summarized in Table 1.

[27] An earlier version of this paper used the sample rank of the covariance measure as an instrument, with large negative coefficients found as below. The problem with this instrument is that it is not clear that errors in rank will be orthogonal to measurement error in the underlying variable. Another superficially attractive instrument is the fraction of workers in a given MSA working in the same industry as a household head. This instrument fails in the "first stage" in that it is not correlated with income-price covariance. The share instrument fails in the "second stage" in that it is correlated with income and education, which themselves are correlated with housing demand. Neighboring correlations are generally uncorrelated with income, education and other demand factors. An alternative to IV estimation in the presence of measurement error is to estimate the reliability ratio in correlation or covariance and then perform an error correction estimate. This approach yields results similar to the IV estimates.

Table 3 presents estimates of equation (15). Column (1) presents coefficient and standard error estimates of a regression of value on demographic variables, with MSA-SIC cell fixed effects and income interactions with MSA and SIC separately included but not reported. Column (2) adds income-asset variance and covariance terms. Column (3) presents the first stage of the two stage least squares estimates, and column (4) the second stage IV estimates. The effects of some demographics are difficult to interpret because there are separate effects estimated for levels and for interactions with income. Education has a positive effect on demand both in levels and in interaction with income, as does family size. Being young (under 30, or between 30 and 40), black or Hispanic has a negative effect on housing owned both in levels and interacted with income.

When variance and covariance terms are added in column (2) of Table 3, we find the expected negative sign on income-price covariance. Variance of income and covariance with nominal interest rates and stock market returns also exert significant negative effects. Somewhat surprisingly, spending on housing does not rise more quickly with income in industries with more rapidly growing wages.

Turning attention to column (3), we find that all ten instrumental variables are significant in the first stage COV(P,y) regression. Suggesting robustness in a rough way, despite large sample size, not all of the demographic covariates are significantly correlated with covariance, as seen in column (3) (almost none have significant effects on the income-correlation interaction instrument).

As expected, the use of instrumental variables increases the estimated effect of covariance on housing investment. The coefficient on COV(P,y) increases in magnitude from -2.8 to -11.8 between OLS (specification (2)) and IV (specification (4)). Both coefficients are significant at a one percent confidence level. To interpret this coefficient, holding income constant, a one standard deviation increase in log covariance COV(lnP,lny) of .01 would generate a decrease in housing purchases of just over ten percent of a household head's annual income. Alternatively, a one standard deviation increase in the level of covariance (including the income interaction) is 636, as reported in Table 1. Multiplying by the estimated coefficient of -11.8 implies a reduction in housing investment of approximately $7,500. A reasonable inference would be that housing purchases fall by approximately one bathroom with a standard deviation increase in covariance.

4.2 Effect of Covariance on the Probability of Housing Purchases

To consider the effect of covariance on the extensive choice between owning and renting housing, I evaluate average decisions and characteristics within MSA-SIC cells. While the effect of log income-price covariance on the intensive margin should surely grow with income, there is no obvious reason to think this would be the case regarding the own-rent decision. Since the correlation and log covariance measures are shared within cells, it is worthwhile in this setting to determine whether covariance effects can be detected at the cell level, at the sacrifice of over one million degrees of freedom. I treat each cell as an independent observation, which is justifiable only in the presence of MSA and SIC fixed effects. Standard errors are robust as throughout.

The cell level tenure choice analysis is presented in Table 4. The dependent variable is the fraction of household heads working in each of 7,396 MSA-SIC cells who rent their housing. The effects of demographic variables are as expected, with cell mean age and variables associated with socioeconomic status generating positive effects on the probability of ownership. The effect of covariance is positive and significant in OLS, and larger but insignificant in IV estimation. The magnitude of the effect of covariance is quite small. Multiplying the IV coefficient of approximately 0.85 in the presence of demographic covariates by the standard deviation of log covariance (.01), yields a decrease of $\frac{85}{100}$ of one percent in the average fraction of homeownership within an MSA-SIC cell. Given the considerable variation that exists across cells in mean homeownership, this is a small effect. Further, the IV estimate is indistinguishable from zero (although this is predictable given the relatively small sample size, and the large number of fixed effects – 56 SIC codes plus 140 MSAs). The significance of the OLS effect is noteworthy, although measurement error tends to bias standard errors, as well as coefficients, downwards. Table 4 thus appears to lend weak evidence of a small effect of covariance on the "extensive" margin of tenure choice.

4.3 Effect of Covariance on the Value of Housing Owned, Conditional on Homeownership

Table 5 reports the estimated effect of the covariance of income on the "intensive" margin of housing value conditional on purchasing housing. The sample size is smaller than in the estimates reported in Table 3 because renters are excluded. These conditional home value results are very similar to the unconditional results reported in Table 3; youth and minority status are associated with small housing values. Income, education, whiteness and family size are associated with large housing assets. Covariance between income and prices again exerts a significant negative effect and this effect appears stronger when instrumental variables are used to overcome attenuation bias due to measurement error. The specification order is the same as in Tables 3 and 4. The IV coefficient in column (4) on COV(P,y) of -7.4 implies, holding income constant, that a one standard deviation increase in log income-price covariance COV(lnP,lny) would be associated with a reduction of approximately 7.4% of a year's income in housing value. Alternatively, a one standard deviation increase in the covariance level would be associated with a reduction of approximately $4,700 in housing value conditional on ownership. We are in theory concerned that homeowners with large covariance values are those with large idiosyncratic investment demand for housing, pursuant to the model and the results of Table 4. This effect would imply a bias towards zero in our estimated effect of covariance. However, given the significant but small effect found on the own-rent decision, we anticipate only a small degree of bias due to selection.

5 Conclusions

Because housing is the most important asset, and labor income the most important source of wealth for most households, we expect intuitively that housing decisions will incorporate the desire to hedge against income risk. Putting some theoretical structure on the question of housing choice with risky prices and income, under what look like reasonable conditions, I find that households optimally purchase less housing on both the intensive and extensive margins as the covariance between housing prices and labor income increases. This theoretical prediction is borne out empirically. On the extensive margin, covariance has a negative effect on the probability of ownership, but significance is marginal and the magnitude of the effect quite small. On the intensive margin, the effect is clearer. I estimate that, on average, an increase of one standard deviation in covariance reduces housing investment by approximately $7,500, or, roughly speaking, one bathroom. An implication is that uninsurable labor income and housing prices, combined with non-diversification of housing investment, act to distort consumption and investment decisions substantially.

The results are interesting both because they extend our understanding of household financial risk and because they suggest that households are, on average, aware of these risks and take some measures to reduce risk. The data are consistent both with a large fraction of households making small housing investment modifications in response to joint income-price risk and with a small fraction of households making large modifications. Existing studies of stock market behavior present ambiguous evidence that households act on labor income-asset return covariance. The result of Heaton and Lucas (2000) leaves open the possibility that only relatively astute entrepreneurs take covariance into account.

The theoretical and empirical results are interesting with respect to stock market behavior. Because homeowners are wealthier on average than renters, financial assets are concentrated in the hands of homeowners. On average, the incomes of these homeowners covary positively with housing prices. For homeowners considering the purchase of stock, there is thus background risk from income, from housing returns, and from the typically positive covariance of the two risks. Over long horizons, I find a positive correlation not only between stock market returns and labor income, but also between stock market returns and housing prices. The consequences for risk aversion over stock returns, and the welfare consequences of incremental investment in equities are worthy of further consideration.

Karl Case, Robert Shiller and Allan Weiss have proposed[28] that derivatives markets in regional housing prices might offset risk attributable to variability in capital gains on housing investment. For similar reasons, Caplin et al. (1997) propose financial instruments to allow homeowners to share home equity with broader markets. Evidently, if households completely

[28] As in Shiller (1993).

insured against house price risk through such markets, there would be no incentive to shift housing consumption or investment with changes in income-price covariance. While the general equilibrium welfare effects of the introduction of such markets are ambiguous, the analysis suggests that such securities, if fairly priced, would have direct benefits for many households. Indeed, given the large average correlation found between income and prices, it appears that households might wish to hold short positions in regional price indices to smooth labor income across states of nature, independent of desire to smooth capital gains.

As a practical matter, most households directly hold few or zero non-housing assets, so that complete insurance against housing risk seems highly unlikely for most of the population. Given this and in light of the analysis presented here, proposals to remove the exemption of imputed rental services and the virtual exemption of capital gains on housing from taxation warrant further consideration. Berkovec and Fullerton (1992) emphasize the attendant implicit risk sharing in housing prices. Assuming strictly positive nominal price changes (and no offsetting reduction in income taxes) a tax on housing capital gains would reduce the covariance between income and prices for homeowners and should hence proportionately reduce the significant consumption and investment distortion estimated above. Again, the general equilibrium welfare consequences are uncertain, but we might expect the presence of income-price covariance to augment the positive effects found by Berkovec and Fullerton. Heterogeneity in income-price covariances across households can be expected to complicate any such analysis.

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Table 1: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
INC	1,082,693	31,465	29,086	1.00	197,927
INC^2	1,082,693	1.84 Billion	4.9 Billion	1.00	39.2 Billion
BLACK	1,082,693	0.10	0.30	0.00	1
INC×BLACK	1,082,693	2,100	8,261.13	0.00	197,927
AGE	1,082,693	42	13.11	17	90
INC×AGE	1,082,693	1,354,855	1,446,073	30	17,600,000
FEMALE	1,082,693	0.28	0.45	0	1
INC×FEMALE	1,082,693	37,118	32,157	1.00	395,854
EDUC	1,082,693	11.28	2.83	1.00	17
INC×EDUC	1,082,693	382,632	420,740.00	2.00	3,364,759
RENTER	1,082,693	0.37	0.48	0	1
VALUE|OWN	753,424	135,927	99,291	5,000	400,000
VALUE	1,082,693	85,489	102,530	0.00	400,000
COV(lnP,lny)	1,082,693	0.01	0.01	-0.33	0.63
COV(P,y)	1,082,693	191	635.56	-22,179	38,812
VAR(lny)	1,082,693	0.01	0.38	0.00	209
INC×VAR(lny)	1,082,693	366	10,574	0.00	9,387,698
VAR(P)	1,082,693	0.05	0.05	0.00	0.65
INC×VAR(P)	1,082,693	1,661	3,094.84	0.00	81,144
CORR(P,y)	1,082,693	0.29	0.43	-1.00	1.00
GROW(y)	1,082,693	1.04	0.06	0.43	7.64
CORR(S,y)	1,082,693	0.46	0.36	-1.00	1.00
CORR(S,P)	1,082,693	0.21	0.40	-1.00	1.00
COV(S,lny)	1,082,693	0.02	0.02	-2.41	1.50
INC×COV(S,lny)	1,082,693	580	1,098	-108,404	72,483
COV(R,lny)	1,082,693	-0.08	0.13	-4.56	2.20
INC×COV(R,lny)	1,082,693	-2,274	5,951	-368,530	200,791

Notes: The level of observation is household heads in the 1990 US Census IPUMS 5 percent sample. Log covariances and Betas are calculated at the cell (MSA-SIC) level. COV(P,y) is equal to household head wage and salary income from the US times the cell level log covariance COV(lnP,lny). CORR(P,y) is the correlation coefficient between log cell mean income and MSA housing prices. R refers to average 30 year mortgage interest rates and S to the S&P index. Variances and covariances of price and log price are identical by the assumption that the hedonic price is equal (and normalized to one) across MSAs).

Table 2: Household Investment Income by Housing Tenure

	OWN	RENT
All	193,448	115,046
Have Investent Income	97,512	28,267
Mean Investment Income	2,470	534
Median Investment Income	10	0
Mean Home Value / Monthly Rent	135,451	470
Median Home Value / Monthly Rent	112,500	437

Notes: Data comes from 1990 US Census microdata (1 % sample). Values are for household heads with identifiable MSA-SIC cells and positive labor income.

Table 3: Value of Housing Owned Regressed on Demographic and Covariance Characteristics

	(1)	(2)	(3)	(4)
DEPENDENT VARIABLE	VALUE	VALUE	COV(P,y)	VALUE
COV(P,y)		-2.821		-11.833
		(0.414)**		(1.569)**
INC	1.299	1.413	-0.032	1.184
	(0.099)**	(0.140)**	(0.000)**	(0.150)**
AGE	1,507.48	1,507.62	0.227	1,508.50
	(27.100)**	(27.091)**	(0.082)**	(27.188)**
FEMALE	10,492.10	10,495.26	2.134	10,530.05
	(383.779)**	(383.490)**	-1.133	(384.033)**
FAMSIZE	3,713.56	3,719.63	1.232	3,738.27
	(99.007)**	(98.983)**	(0.307)**	(99.344)**
EDUC	3,341.63	3,338.33	0.662	3,345.85
	(56.600)**	(56.635)**	(0.169)**	(56.945)**
UNDER30	-1,250.76	-1,263.34	5.153	-1,243.29
	-766.594	-766.133	(2.329)*	-768.619
OVER30UNDER40	-7,567.92	-7,587.11	1.304	-7,603.95
	(484.178)**	(484.063)**	-1.472	(485.695)**
BLACK	-16,352.95	-16,352.05	0.97	-16,359.68
	(430.441)**	(430.652)**	-1.446	(433.134)**
NOTHISPANIC	19,062.77	18,921.86	-19.706	18,648.52
	(518.469)**	(519.036)**	(1.551)**	(522.990)**
INC^2	0	0	0	0
	(0.000)**	(0.000)**	0	(0.000)**
INC×AGE	-0.006	-0.006	0	-0.006
	(0.001)**	(0.001)**	(0.000)**	(0.001)**
INC×FEMALE	-0.172	-0.172	0	-0.174
	(0.015)**	(0.015)**	(0.000)**	(0.016)**
INC×FAMSIZE	0.027	0.027	0	0.026
	(0.003)**	(0.003)**	(0.000)**	(0.003)**
INC×EDUC	0.058	0.058	0	0.058
	(0.002)**	(0.002)**	(0.000)**	(0.002)**
INC×UNDER30	-0.592	-0.592	0	-0.593
	(0.024)**	(0.024)**	(0.000)**	(0.024)**
INC×OVER30UNDER40	-0.006	-0.006	0	-0.006
	-0.013	-0.013	(0.000)*	-0.013
INC×BLACK	-0.381	-0.381	0	-0.381
	(0.019)**	(0.019)**	0	(0.019)**
INC×NOTHISPANIC	-0.019	-0.015	0.001	-0.006
	-0.021	-0.021	(0.000)**	-0.021
INC×Grow(y)		-0.108	0.032	0.141
		-0.102	(0.000)**	-0.117
COV(S,y)		-1.482	0.043	-1.069
		(0.321)**	(0.001)**	(0.338)**
COV(R,y)		-0.199	0.007	-0.132
		(0.053)**	(0.000)**	(0.056)*
INC×VAR(lny)		-0.022	0.001	-0.009
		(0.007)**	(0.000)**	-0.017
INC×CORRN1			0.002	
			(0.000)**	
INC×CORRN2			0.001	
			(0.000)**	
INC×CORRN3			0.001	
			(0.000)**	
INC×CORRN4			0.001	
			(0.000)**	
INC×CORRN5			0.001	
			(0.000)**	
INC×CORRN6			0.001	
			(0.000)**	
INC×CORRN7			0.002	
			(0.000)**	
INC×CORRN8			0.001	
			(0.000)**	
INC×CORRN9			0.002	
			(0.000)**	
INC×CORRN10			0.001	
			(0.000)**	
Constant	0	0	0	0
	-70.957	-70.951	-0.246	-71.045
Observations	1,082,693	1,082,693	1,081,552	1,081,552
R-squared	0.38	0.38	0.64	N/A
Comment	OLS	OLS	IV Stage 1	IV Stage 2

Notes: Robust standard errors in parentheses, * denotes significant at 5%, ** at 1%. Indicator variables for MSA-SIC cells and income interactions with MSA and SIC fixed effects are included but not reported. Also included are level and income interactions of marital status indicators. VALUE is equal to the dollar value of household's housing unit if the household owner occupies, or zero if the household rents. INC is income. COV(P,y) is the covariance between income and house prices for a household head. UNDER 30 and OVER30UNDER40 refer to age. COV(S (R),y) is the covariance between income and stock market returns (nominal interest rates). CORRNX is the correlation between income and house prices in a household head's industry (SIC) in the Xth nearest MSA. These 10 variables are instrumental variables in specifications (3) and (4).

Table 4: Cell Level Fraction of Household Heads Renting Housing Regressions

	(1)	(2)	(3)	(4)
DEPENDENT VARIABLE	RENTER	RENTER	COV(lnP,lny)	RENTER
COV(lnP,lny)		0.415		0.847
		(0.179)*		(0.957)
INC	-0.000	-0.000	-0.000	-0.000
	(0.000)**	(0.000)**	(0.000)	(0.000)**
AGE	-0.011	-0.011	0.000	-0.011
	(0.002)**	(0.002)**	(0.000)*	(0.003)**
FEMALE	-0.004	-0.001	-0.003	0.001
	(0.034)	(0.034)	(0.002)	(0.034)
FAMSIZE	-0.016	-0.016	0.001	-0.016
	(0.010)	(0.010)	(0.001)	(0.011)
EDUC	-0.010	-0.010	0.001	-0.010
	(0.004)*	(0.004)*	(0.000)*	(0.004)*
UNDER30	0.107	0.097	0.012	0.092
	(0.068)	(0.066)	(0.004)**	(0.069)
OVER30UNDER40	-0.031	-0.036	0.006	-0.039
	(0.042)	(0.042)	(0.003)*	(0.043)
BLACK	0.090	0.092	-0.005	0.094
	(0.034)**	(0.034)**	(0.003)	(0.034)**
NOTHISPANIC	-0.120	-0.120	0.002	-0.121
	(0.043)**	(0.043)**	(0.003)	(0.044)**
GROW(y)		-0.037	0.033	-0.051
		(0.037)	(0.003)**	(0.044)
COV(S,lny)		-0.091	0.086	-0.127
		(0.103)	(0.007)**	(0.132)
COV(R,lny)		-0.025	-0.003	-0.023
		(0.017)	(0.001)*	(0.017)
VAR(lny)		0.001	-0.000	0.001
		(0.002)	(0.000)**	(0.001)
CORR5N1			0.002	
			(0.000)**	
CORR5N2			0.001	
			(0.000)**	
CORR5N3			0.000	
			(0.000)	
CORR5N4			0.000	
			(0.000)	
CORR5N5			-0.001	
			(0.000)	
CORR5N6			0.000	
			(0.000)	
CORR5N7			0.000	
			(0.000)	
CORR5N8			0.001	
			(0.000)*	
CORR5N9			0.001	
			(0.000)*	
CORR5N10			0.000	
			(0.000)	
Constant	1.071	1.120	-0.060	1.145
	(0.160)**	(0.161)**	(0.010)**	(0.177)**
Observations	7396	7396	7396	7396
R-squared	0.62	0.63	0.29	0.62

Notes: Robust standard errors in parentheses. * Denotes significance at 5%, ** at 1%. All variables refer to MSA - SIC cell mean values. RENTER indicates that a household rents their housing. INC is income. COV(lnP,lny) is the covariance between percentage changes in MSA-SIC cell mean income and house prices for a household head. UNDER 30 and OVER30UNDER40 refer to age. COV(S (R),y) is the covariance between income and stock market returns (nominal interest rates). CORRNX is the correlation between income and house prices in a household head's industry (SIC) in the Xth nearest MSA. These 10 variables are instrumental variables in specifications (3) and (4). Also included, but unreported are marital status, MSA and SIC dummies.

Table 5: Value of Housing Owned, Homeowners Only

	(1)	(2)	(3)	(4)
DEPENDENT VARIABLE	VALUE|OWN	VALUE|OWN	COV(P,y)	VALUE|OWN
COV(P,y)		-2.161		-7.389
		(0.338)**		(1.492)**
INC	0.949	1.094	-0.011	1.076
	(0.100)**	(0.134)**	(0.000)**	(0.135)**
AGE	566.593	566.876	0.182	567.452
	(27.730)**	(27.730)**	(0.112)	(27.791)**
SEX	14,504.872	14,502.568	0.154	14,517.946
	(486.006)**	(486.116)**	(1.837)	(487.030)**
FAMSIZE	1,175.403	1,179.257	1.101	1,194.964
	(110.969)**	(110.982)**	(0.447)*	(111.263)**
EDUC	4,679.676	4,678.734	1.037	4,687.120
	(68.043)**	(68.055)**	(0.254)**	(68.243)**
UNDER30	-279.718	-267.289	8.080	-260.138
	(856.006)	(856.173)	(3.493)*	(858.533)
OVER30UNDER40	-4,954.975	-4,960.520	1.996	-4,967.163
	(495.630)**	(495.624)**	(2.024)	(496.736)**
BLACK	-19,755.990	-19,761.873	2.903	-19,805.310
	(614.494)**	(614.445)**	(2.493)	(617.325)**
NOTHISPANIC	9,882.293	9,748.612	-26.561	9,532.603
	(688.768)**	(689.283)**	(2.611)**	(692.085)**
INC^2	-0.000	-0.000	-0.000	-0.000
	(0.000)**	(0.000)**	(0.000)**	(0.000)**
INC×AGE	-0.004	-0.004	-0.000	-0.004
	(0.001)**	(0.001)**	(0.000)*	(0.001)**
INC×FEMALE	-0.311	-0.311	-0.000	-0.312
	(0.015)**	(0.015)**	(0.000)	(0.015)**
INC×FAMSIZE	0.016	0.016	-0.000	0.015
	(0.003)**	(0.003)**	(0.000)*	(0.003)**
INC×EDUC	0.041	0.041	-0.000	0.041
	(0.002)**	(0.002)**	(0.000)**	(0.002)**
INC×UNDER30	-0.428	-0.428	-0.000	-0.428
	(0.024)**	(0.024)**	(0.000)**	(0.024)**
INC×OVER30UNDER40	-0.060	-0.060	-0.000	-0.060
	(0.011)**	(0.011)**	(0.000)*	(0.011)**
INC×BLACK	-0.249	-0.249	-0.000	-0.249
	(0.021)**	(0.021)**	(0.000)	(0.021)**
INC×NOTHISPANIC	0.064	0.067	0.001	0.073
	(0.020)**	(0.020)**	(0.000)**	(0.020)**
INC×GROW(y)		-0.153	0.009	-0.131
		(0.092)	(0.000)**	(0.094)
COV(S,y)		-0.588	0.039	-0.378
		(0.285)*	(0.001)**	(0.299)
COV(R,y)		-0.126	0.008	-0.087
		(0.047)**	(0.000)**	(0.050)
INC×VAR(lny)		0.111	0.059	0.439
		(0.087)	(0.000)**	(0.136)**
INC×CORRN1			0.002	
			(0.000)**	
INC×CORRN2			0.001	
			(0.000)**	
INC×CORRN3			0.001	
			(0.000)**	
INC×CORRN4			0.001	
			(0.000)**	
INC×CORRN5			0.001	
			(0.000)**	
INC×CORRN6			0.001	
			(0.000)**	
INC×CORRN7			0.002	
			(0.000)**	
INC×CORRN8			0.001	
			(0.000)**	
INC×CORRN9			0.002	
			(0.000)**	
INC×CORRN10			0.001	
			(0.000)**	
Constant	-12,526.508	-12,527.645	-0.247	-12,545.816
	(81.893)**	(81.890)**	(0.396)	(82.035)**
Observations	661,934	661,934	660,987	660,987
R-squared	0.31	0.31	0.66	N/A

Notes: Robust standard errors in parentheses, * denotes significant at 5%, ** at 1%. Indicator variables for MSA-SIC cells and income interactions with MSA and SIC fixed effects are included but not reported. Also included are level and income interactions of marital status indicators. VALUE is equal to the dollar value of household's housing unit if the household owner occupies, or zero if the household rents. INC is income. COV(P,y) is the covariance between income and house prices for a household head. UNDER 30 and OVER30UNDER40 refer to age. COV(S (R),y) is the covariance between income and stock market returns (nominal interest rates). CORRNX is the correlation between income and house prices in a household head's industry (SIC) in the Xth nearest MSA. These 10 variables are instrumental variables in specifications (3) and (4).