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Consumption and Investment Motives and the Portfolio Choices of Homeowners

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Abstract

This article investigates the portfolio choices of homeowners, taking into account the investment constraint introduced by Henderson and Ioannides (1983). This constraint requires housing investment by homeowners to be at least as large as housing consumption. It is shown that when the constraint is binding, the homeowner's optimal portfolio is ineffcient in a mean-variance sense. Thus, portfolio inefficiency is not an indication that consumers are irrational or careless in their financial decisions. Instead, inefficiency can be seen as the result of a rational balancing of the consumption benefits and portfolio distortion associated with housing investment.

Key Words: portfolio, overinvestment, homeownership, mean-variance inefficient

1. Introduction

Owner-occupied housing is a major investment for many households in the U.S. and other countries. However, unlike stocks and bonds and other elements of the portfolio, owner-occupied housing provides significant consumption benefits. Acquisition of such housing is thus driven by dual consumption and investment motives, a fact that is now widely recognized in the housing literature.[1]

Despite this awareness, the literature has left mostly unexplored an important issue related to housing's dual role: the effect of housing consumption and investment motives on the structure of consumer portfolios. It is sometimes alleged that consumers ''overinvest'' in housing, which leaves most portfolios inadequately diversified. Remarkably, however, there has been no formal analysis of the overinvestment issue.[2]

The purpose of the present article is to provide such an analysis. To derive results, the article combines the housing investment-consumption model of Henderson and Ioannides (1983) with the standard mean-variance portfolio framework, as presented by Fama and Miller (1972). The key element of the Henderson–Ioannides model is a constraint governing the investment and consumption choices of homeowners. This *investment* constraint requires that h, the quantity of housing owned, is at least as large as h_c, the quantity consumed, so that $h \geq h_c$. Violation of this constraint $(h < h_c)$ would imply that the homeowner owns only a portion of the housing that he consumes, indicating that his house is partly owned by another individual. Despite some experimentation with ''equity sharing'' in high-cost regions such as California, this partial-ownership arrangement is typically infeasible.[3]

When the investment constraint is binding, an increase in housing consumption can only be achieved by a simultaneous increase in housing investment. As a result, the consumption and investment motives are intertwined. By contrast, these motives are separable when the investment constraint is not binding, with $h > h_c$. In this case, the homeowner owns rental property, and housing consumption can be increased without affecting h by allocating more of the fixed investment to direct consumption.[4]

The analysis explores the effect of the housing investment constraint on portfolio choice. It is shown that portfolio selection is governed by the usual rules when the investment constraint is not binding. The optimal portfolio is then a mean-variance-efficient blend of a ‘‘market'' portfolio (which includes housing) and the riskless asset. When the investment constraint is binding, by contrast, the optimal portfolio is mean-variance *inefficient*. In particular, the portfolio's expected return could be *raised* with no increase in risk by *reducing* the housing investment and making appropriate adjustments in other assets. The consumer tolerates this inefficiency, because, when the constraint is binding, a reduction in housing investment necessarily implies a reduction in housing consumption, with an attendant loss of benefits. The homeowner thus balances consumption gains against distortion of the portfolio in choosing h. In the nonbinding case, by contrast, consumption and portfolio choices are independent. Overall, the analysis provides the first formal treatment of housing overinvestment by consumers.[5]

Although the investment constraint distorts the choices of owner-occupiers, the constraint does not apply to renter households. Since the housing which they consume is rented, the amount of owned housing (which generates rental income) can be smaller or larger than h_c. Freedom from the investment constraint comes at a cost, however, because renters forsake the tax subsidy enjoyed by homeowners. The resulting trade-off, and the associated tenure-choice problem, was investigated by Henderson and Ioannides (1983) and is not a concern of the present analysis. Instead, the discussion focuses exclusively on the portfolio decisions of homeowners.

The effect of alternate assumptions is also investigated. The analysis explores the case where capital markets are imperfect, with riskless borrowing tied to housing investment via a mortgage loan, and the case where owner-occupied and rental housing are distinct assets. Finally, the article generates and tests some empirical predictions. It is shown that holding total investment and housing ownership h constant, portfolio risk and return will be lower for an individual who consumes all of his housing ($h_c = h$) than for an individual who rents out a portion. These risk-return differences are shown to result from a different mix of nonhousing assets in the portfolios of the two individuals. This asset-mix prediction is tested using data from the *Survey of Consumer Finances*.

2. Basic Analysis

2.1. The Model

Following Henderson and Ioannides, let homeowner utility depend on current consumption of both housing (h_c) and a numeraire non-housing good (x), and on consumption in future periods, which depends on the random total return R from the investment portfolio. Letting y denote future income, the homeowner's objective function is thus

$$U(x, h_c) + \delta E[V(R + y)] \tag{1}$$

where U gives the utility from current consumption, V is an indirect utility function that gives future utility conditional on wealth, and $\delta < 1$ is a discount factor (E is the expectation operator). Both U and V are strictly concave functions.

Units are chosen so that the purchase price of one unit of housing equals a dollar. In addition to housing, the homeowner may select from among $m + 1$ additional investment assets, none of which affords consumption benefits.[6] The dollar amount of asset i purchased is denoted q_i, $i = 0, 1, \ldots, m$, with q_0 giving investment in the riskless asset. For simplicity, short selling is ruled out for all risky assets including housing, so that $q_i \geq 0$ holds for $i \neq 0$, as does $h \geq 0$. In the main part of the analysis, unlimited short selling of the riskless asset, which corresponds to riskless borrowing, is allowed (borrowing occurs when $q_0 < 0$). In section 3, capital market imperfections are introduced by assuming that riskless borrowing is possible only through a mortgage, which is secured by housing investment.

The homeowner must satisfy the investment constraint

$$h \geq h_c \tag{2}$$

along with the current-period budget constraint

$$x = w - \left(h + \sum_{i=0}^{m} q_i \right) + s(h - h_c) \tag{3}$$

where w is initial wealth. The last term in (3) gives the homeowner's rental income, which equals the (after-tax) rent per unit of housing, s, times the amount of owned housing that is rented out, $h - h_c$. Rearranging, (3) reduces to

$$x = w - I - sh_c \tag{4}$$

where

$$I = (1 - s)h + \sum_{i=0}^{m} q_i \tag{5}$$

equals the homeowner's investment net of actual and imputed rental income.[7]

The total return on the homeowner's portfolio is given by

$$R = r_h h + \sum_{i=0}^{m} r_i q_i \tag{6}$$

where r_h and r_i, $i = 0, 1, \ldots, m$, are the total after-tax returns per dollar invested in housing and the other assets (i.e., one plus the net return). While the return r_0 on the riskless asset is nonstochastic, the returns r_h and r_i, $i = 1, 2, \ldots m$, are assumed to be normal random variables with expected values $\bar{r}_h$ and $\bar{r}_i$, $i = 1, 2, \ldots, m$.

Several aspects of the return to housing investment deserve note. First, r_h does not include rental income, which is already accounted for in (5). Instead, the housing return is due solely to capital appreciation. In addition, unlike the returns to securities, which are the same nationwide for all investors in a given tax bracket, both r_h and the purchase price of housing will depend on local market conditions. For simplicity, this idiosyncratic aspect of housing investment is ignored in the ensuing analysis. Finally, it is implicity assumed that owner-occupied and rental housing are indistinguishable as assets. While defensible as an approximation, this assumption may not be entirely accurate. The effect of assuming that the two types of housing are distinct assets is considered below.

Under the above assumptions, the total portfolio return R from (6) is itself a normal random variable with expected value

$$\bar{R} = \bar{r}_h h + r_0 q_0 + \sum_{i=1}^{m} \bar{r}_i q_i \tag{7}$$

and standard deviation

$$\sigma = \left(\theta_{hh} h^2 + 2 \sum_{i=1}^{m} h q_i \theta_{hi} + \sum_{i=1}^{m} \sum_{j=1}^{m} q_i q_j \theta_{ij} \right)^{1/2} \tag{8}$$

where θ_{hh} and θ_{ii}, $i = 1, 2, \ldots, m$, are the variances of r_h and r_i, θ_{ij} is the covariance of returns between assets i and j, and θ_{hi} is the covariance between housing and asset i.

As explained by Fama and Miller (1972), (7) and (8) can be used to rewrite the expectation in (1) in terms of the portfolio structure. First, observe that since R is normal, the random variable $z = (R - \bar{R})/\sigma$ has a standard normal distribution. Rearranging, R can then be written in terms of $\bar{R}$, σ, and the standard normal variable:

$$R = \bar{R} + \sigma z \tag{9}$$

Then, letting $\phi(\cdot)$ denote the standard normal density function, the objective function (1) can be rewritten as

$$U(x, h_c) + \delta \int V(\bar{R} + \sigma z + y) \phi(z) dz \tag{10}$$

The homeowner's problem is to select values for the choice variables that maximize (10) subject to (2), (4), (5), (7), and (8). It is useful to solve this problem in two stages. In the first stage, the asset levels q_i, $i = 0, i, \ldots, m$, are chosen optimally with h, I, and σ held fixed. The goal is to maximize $\bar{R}$ conditional on h, I, and σ, generating an efficient portfolio for a given housing investment. In the second stage, h_c, h, I, and σ are chosen optimally, recognizing that $\bar{R}$ depends on the latter variables via the first-stage solution. To appraise the effect of the investment constraint (2) on portfolio choice, the overall solution can be compared in the cases where the constraint is alternatively binding and nonbinding.

2.2. The First-stage Problem

To understand choice of the efficient portfolio conditional on h, it is useful to review the solution to the unconditional problem, where all the assets including housing are chosen to maximize $\bar{R}$. As is well-known, the resulting value of $\bar{R}$ lies on an ''efficient line'' in $(\sigma, \bar{R})$ space, which gives the maximal $\bar{R}$ for each level of risk σ (I is held fixed). At the intercept of the efficient line, shown in figure 1, the entire amount I is invested in the riskless asset, while at point A, all funds are allocated to risky assets (A represents the ''market portfolio'').

Now solve the same problem with h held fixed. The goal is then to maximize $\bar{R}$ holding h, I, and σ fixed, and the solution yields a ''fixed-h'' efficiency locus, whose equation is written

$$\bar{R} = \bar{R}(h, I, \sigma) \tag{11}$$

For each value of h, the graph of (11) yields a different, strictly concave curve, as shown in figure 1. It is easy to see that the efficient line from the unconditional problem must be

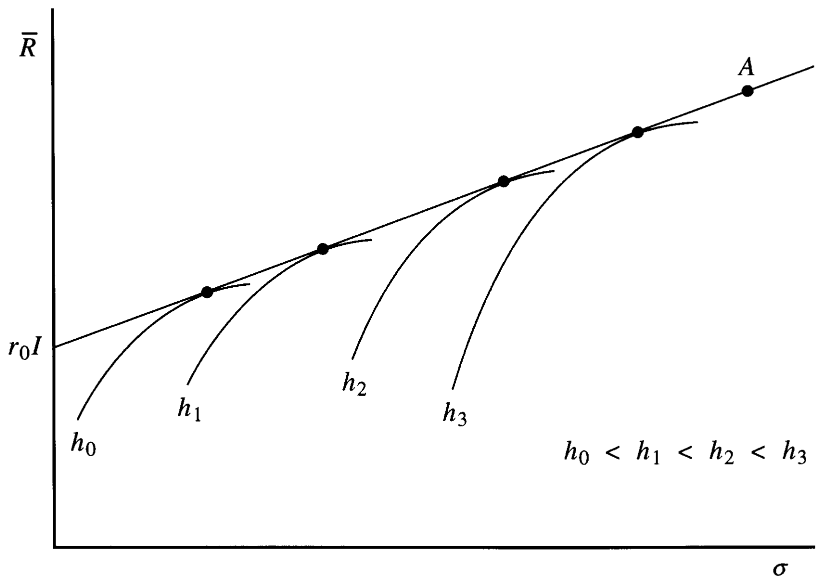

Figure 1. The efficient line and fixed-h efficiency locii.

the *upper envelope* of the fixed-h loci, as seen in the figure. To see why, observe that an alternative way of solving the unconditional problem is to look across conditional solutions at a given σ, choosing the h value that leads to the highest expected portfolio return. Thus, the $\bar{R}$ achieved in the unconditional problem is equal to the value on the *highest* fixed-h efficiency locus at the given σ, yielding the envelope result.

The h value on a locus can be inferred from its tangency point with the efficient line, which indicates the extent of investment in the market portfolio and thus the level of housing investment. Because spending on the market portfolio rises moving up along the line, it follows that efficiency loci lying farther to the right have higher values of h, as shown in figure 1. Letting $\hat{\sigma}(h)$ denote the σ value at which the locus with the given h is tangent to the efficient line, it follows that $\hat{\sigma}(h)$ is increasing in h.

An additional property of the efficiency loci is critical in the following analysis. This property, which is established in the appendix, is stated as follows:

$$\frac{\partial \bar{R}(h, I, \sigma)}{\partial h} < (>) 0 \quad \text{as} \quad \sigma < (>) \hat{\sigma}(h) \tag{12}$$

To understand these inequalities, start at the point on the h_0 locus in figure 2 where $\sigma = \sigma'$. This point is to the left of the tangency, satisfying $\sigma' < \hat{\sigma}(h_0)$. An increase in h holding σ fixed moves $\bar{R}$ onto a locus whose tangency is farther to the right, and, as can be seen in figure 2, this movement leads to a decline in $\bar{R}$. This confirms the first part of

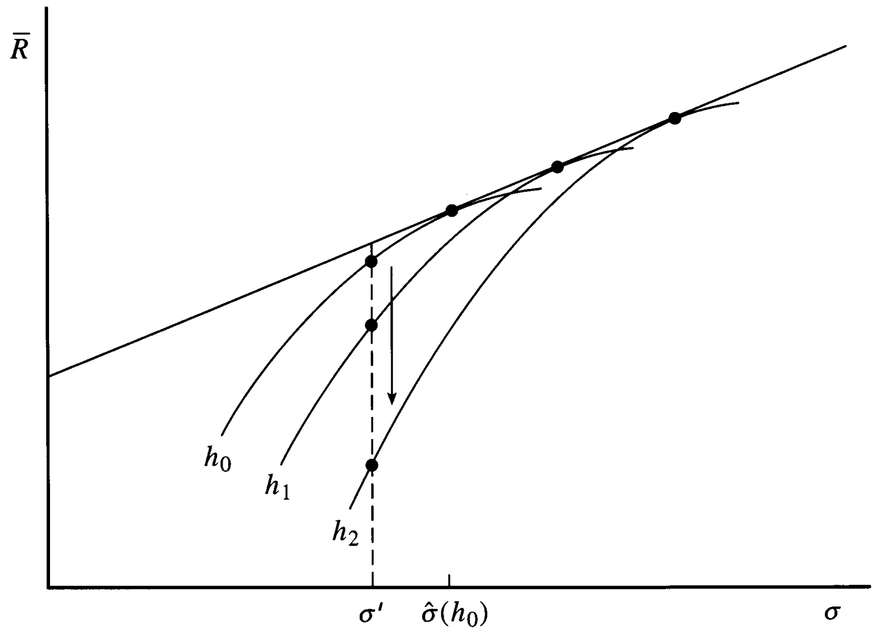

Figure 2. $\partial \bar{R}/\partial h < 0$ to the left of tangency.

(12), and the second set of inequalities can be verified similarly.[8] Finally, given (12), it is clear that

$$\frac{\partial \bar{R}(h, I, \sigma)}{\partial h} = 0 \quad \text{when} \quad \sigma = \hat{\sigma}(h) \tag{13}$$

which restates the fact that the locus tangent to the efficient line yields the highest $\bar{R}$ at a given σ.

2.3. The Second-stage Problem

To solve the second-stage problem, it is useful to first derive the homeowner's indifference curves in $(\sigma, \bar{R})$ space. Setting $U + \delta \int V(\bar{R} + \sigma z + y)\phi(z)dz$ equal to a constant, differentiation with respect to $\bar{R}$ and σ yields $d\bar{R} \int V'\phi dz + d\sigma \int zV'\phi dz = 0$. Solving for $\partial\bar{R}/\partial\sigma$ gives the marginal rate of substitution between return and risk,

$$MRS_{\bar{R},\sigma} = -\frac{\int zV'\phi dz}{\int V'\phi dz} > 0 \tag{14}$$

Equation (14) indicates that the risk-return indifference curves are upward sloping, and it may also be shown that the curves are strictly convex. Both properties follow from consumer risk aversion, which is reflected in strict concavity of V (see Fama and Miller, 1972).

Consider now the second-stage problem, where the homeowner chooses h_c, h, I, and σ to maximize utility. Substituting (4) and (11) into the objective function (10), the homeowner's problem is to maximize

$$U(w - I - sh_c, h_c) + \delta \int V[\bar{R}(h, I, \sigma) + \sigma z + y]\phi(z)dz \tag{15}$$

subject to the investment constraint $h - h_c \geq 0$. Letting η denote the multiplier associated with this constraint, the Kuhn–Tucker optimality conditions for maximization of (15) are

$$\sigma: \quad \delta \int V'\left(\frac{\partial \bar{R}}{\partial \sigma} + z\right)\phi dz = 0 \tag{16}$$

$$I: \quad \delta \int V' \frac{\partial \bar{R}}{\partial I}\phi dz - U_x = 0 \tag{17}$$

$$h: \quad \delta \int V' \frac{\partial \bar{R}}{\partial h}\phi dz + \eta = 0 \tag{18}$$

$$h_c: \quad U_h - sU_x - \eta = 0 \tag{19}$$

along with $\eta(h - h_c) = 0$, $h \geq h_c$, and $\eta \geq 0$ (the U subscripts denote partial derivatives).

Using the equality $\partial R/\partial I = r_0$, which is established in the appendix, rearrangement of (17) yields

$$\frac{U_x}{\delta \int V' \phi dz} = r_0 \tag{20}$$

This condition indicates that I is set optimally when the marginal rate of substitution between current and future consumption is equal to the riskless return. Next, rearrangement of (16) together with (14) yields[9]

$$MRS_{\bar{R},\sigma} = \frac{\partial \bar{R}}{\partial \sigma} \tag{21}$$

which indicates that σ is set optimally when a risk-return indifference curve is tangent to a fixed-h efficiency locus.

The location of this tangency relative to the efficient line in figure 1, which is of central interest, depends on whether or not the investment constraint is binding. If the constraint is nonbinding, so that $\eta = 0$, then (18) implies $\partial \bar{R}/\partial h = 0$. By (13), this equality yields $\sigma = \hat{\sigma}(h)$, indicating that the solution must lie at a point of tangency between a fixed-h efficiency locus and the efficient line. Therefore, the tangency in (21) between an efficiency locus and a risk-return indifference curve occurs where the locus is itself tangent

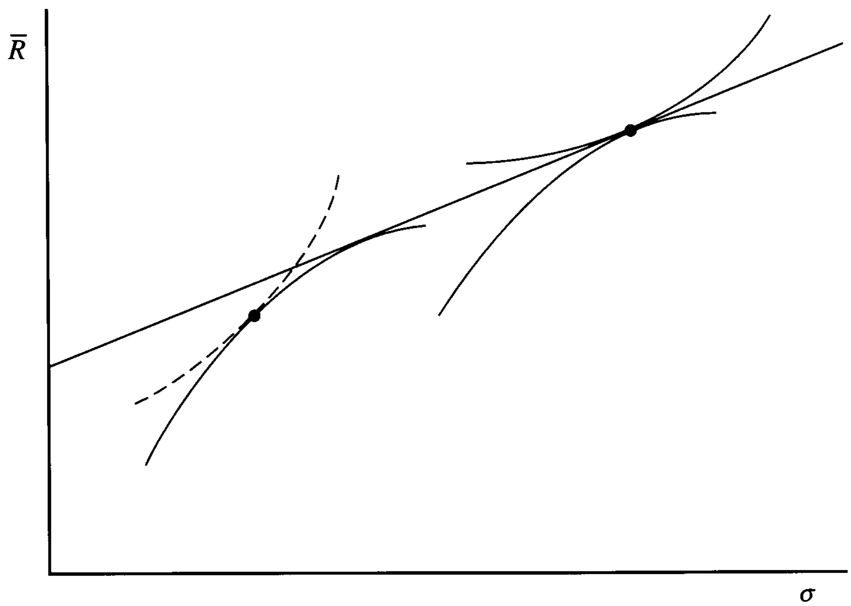

Figure 3. Binding vs. nonbinding solutions.

to the efficient line, as shown in the right portion of figure 3. The chosen portfolio is thus mean-variance efficient.

An additional conclusion in the nonbinding case follows from rearrangement of (19). This yields $U_h/U_x = s$, indicating that the marginal rate of substitution between housing and the nonhousing good equals the rental price per unit. Housing consumption is thus chosen to satisfy the usual marginal condition, implying that the consumption point lies on the demand curve.

Now suppose that the investment constraint is binding, so that $\eta > 0$.[10] Equation (18) then implies $\partial\bar{R}/\partial h < 0$, indicating that for housing investment to be optimal, a *marginal decrease in* h *must increase the portfolio return.* Given (12), this condition then implies $\sigma < \hat{\sigma}(h)$, which indicates that the optimal point lies downhill on a fixed-h efficiency locus from the point of tangency with the efficient line. This outcome is shown in the left portion of figure 3 (note that the two tangencies reflect different preferences).

The major implication of this result is that the optimal portfolio is *inefficient* in a mean-variance sense, lying below the efficient line. From (12), it is clear that, holding I fixed, the portfolio's return could be raised without increasing its risk by *reducing* the housing investment and making appropriate adjustments in the other assets. Given (12), this would move the homeowner to a higher efficiency locus, increasing $\bar{R}$. However, because of the binding investment constraint, the individual does not benefit from this reallocation. The reason is that the reduction in h necessarily implies a reduction in h_c, and thus a loss of consumption benefits. The homeowner tolerates distortion of his portfolio in order to secure these benefits.

The same conclusion applies to housing consumption, which is distorted to serve the investment motive. Rearrangment of (19) yields $U_h/U_x > s$, indicating that the housing consumption point lies to the *left* of the demand curve. The homeowner tolerates the resulting underconsumption of housing in order to avoid excessive distortion of the portfolio. From the first-order conditions, it can be seen that the consumption and portfolio distortions must exactly balance at the optimum. Eliminating η in (18) and (19) yields

$$\frac{U_h}{U_x} - s = -\frac{\delta}{U_x}\int V'\frac{\partial\bar{R}}{\partial h}\phi dz \tag{22}$$

where the left-hand side is the net consumption gain from an increase in h (marginal valuation minus rental cost), and the right-hand side is the utility loss from the additional portfolio distortion. In the binding case, both terms are positive.

Stated differently, the outcome in the binding case reflects both *overinvestment in housing* and *underconsumption of housing*. In the nonbinding case, investment and consumption decisions are separable, and neither choice is distorted. Summarizing yields

Proposition 1. When the investment constraint is not binding, the homeowner's optimal portfolio is mean-variance efficient, and housing consumption lies on the demand curve. When the investment constraint is binding, the optimal portfolio is inefficient, with a higher $\bar{R}$ achievable by reducing h (implying $\sigma < \hat{\sigma}(h)$). In addition, housing consumption lies to the left of the demand curve.

2.4. When Will the Investment Constraint Bind?

Given the importance of the investment constraint in determining portfolio performance, it is natural to explore the circumstances that lead the constraint to bind. This is done by carrying out comparative-static analysis of the nonbinding case, focusing on the parameters δ, w, y, and s. If a change in a given parameter causes h to fall and h_c to rise under the nonbinding solution, then a large enough change will cause the investment constraint to bind. If, on the other hand, a parameter change moves h and h_c in the same direction or has ambiguous effects, nothing can be said about its impact on the constraint. Henderson and Ioannides (1983) also used this approach, and some of their results are replicated below.[12]

To begin, observe that when the investment constraint is not binding, h and σ are chosen to maximize $\delta \int V[\bar{R}(h, I, \sigma) + \sigma z + y]\phi dz$. Let the maximized value of this expression be denoted $\delta Q(I, y)$. Also, when the constraint is not binding, h_c is chosen to maximize $U(w - I - sh_c, h_c)$. Let $T(w - I, s)$ denote the indirect utility function resulting from this maximization problem. Under the maintained assumptions, both Q and T are strictly concave in their first arguments. The homeowner in the nonbinding case then chooses I to maximize

$$T(w - I, s) + \delta Q(I, y) \tag{23}$$

To analyze the first comparative-static effect, suppose that the discount factor δ falls. Then future consumption is less highly valued, and the homeowner responds by decreasing I, as can be seen from (23). Since this means less investment in the market portfolio, h falls. However, with $w - I$ rising, h_c increases, so that $h - h_c$ falls. A sufficiently large decline in δ thus reduces $h - h_c$ to zero, at which point the investment constraint binds. The same outcome occurs with a sufficiently large increase in future income y. A higher y lowers I, which depresses h, while h_c rises in response to the increase in $w - I$. Eventually, $h - h_c$ reaches zero.

The investment constraint is thus likely to bind for a homeowner who is impatient (with a low discount factor) or who has a large future income. Since such individuals have little incentive to invest for the future, acquisition of housing will be driven largely by the consumption motive, and a binding investment constraint is the likely result. Unfortunately, unambiguous statements about the effects of w and s cannot be made.[13]

2.5. Additional Points

It is important to realize that the results for the nonbinding case in Proposition 1 apply to renter households, who rent the housing that they consume. Because h_c bears no relation to the quantity of housing owned for such households, the investment constraint does not apply. As a result, any housing investment by renters is undistorted by the consumption motive. While the absence of this distortion might appear to make renting the preferred tenure mode, this conclusion ignores a key disadvantage of renting: a cost per unit of housing that is higher than the homeowner's cost s. Henderson and Ioannides (1983) derived such a cost relationship by appeal to the ''renter externality,'' where property abuse by renters pushes costs above those borne by more careful homeowners. A simpler tax-based argument, however, links higher renter costs to nontaxation of the homeowner's imputed rental income.[14] The upshot of either approach is that renting entails a cost disadvantage that may or may not offset the gain from absence of the investment constraint, making the preferred tenure mode ambiguous. Whatever the outcome, the option of renting puts an upper bound on the distorting potential of the investment constraint. Individuals who, as homeowners, would substantially overinvest in housing are likely to choose renting instead.[15]

An additional point is that a market portfolio does not exist in the above framework, in contrast to the standard model. In other words, all portfolios need not contain the same mix of risky assets. To see this most simply, observe that the mix of risky nonhousing assets varies along a given fixed-h efficiency locus. Therefore, in the binding case, a difference in preferences that yields different tangencies on a given locus will necessarily affect the asset mix.[16] The absence of a market portfolio is noted in a different context by Mayers (1972), who analyzes portfolio choice when the consumer owns nonmarketable human capital.

A final point concerns justification for the general practice of ignoring consumption benefits from assets, which is a hallmark of the portfolio literature but is avoided here. Has the literature made a fundamental error, or can this approach be justified under proper assumptions? The answer is that consumption benefits can be ignored in the portfolio decision when preferences take a special form. The main requirement is that asset-based consumption must be a *perfect substitute for regular consumption*, so that the utility function is linear. In addition, the marginal utility of asset-based consumption *must be equal to the asset's rental price*. This latter assumption is in fact an equilibrium outcome in a world with linear preferences (otherwise corner solutions emerge). In the present context, these assumptions mean that preferences must satisfy $U(x, h_c) = x + sh_c$. The impact of this specification can be seen formally in (19), where $U_x = 1$ and $U_h = s$ yield $\eta = 0$, indicating that the investment constraint is nonbinding and that the portfolio is undistorted by the consumption motive. Intuition for this result comes from rearranging the budget constraint (4) to yield $U = w - I$, which indicates that for a given I, the mix of x and h_c is irrelevant to the consumer. Thus, h_c can be set at a level that does not distort the portfolio's composition.

3. Alternate Assumptions

3.1. Restrictions on Riskless Borrowing

The maintained assumption of unlimited riskless borrowing is unrealistic. Real-world capital markets are instead imperfect, with sizeable loans seldom granted in the absence of collateral. Car loans and mortgages are the most common type of secured lending, but borrowing against portfolios of financial assets (via margin accounts) also occurs. Since the present focus is on housing, the collateral requirement is incorporated into the analysis by assuming that riskless borrowing must be secured by housing assets. In other words, all riskless borrowing is mortgage debt.

To incorporate this modification, the model must include a housing collateral constraint, which is written

$$\alpha h + q_0 \geq 0 \tag{24}$$

where $0 < \alpha \leq 1$ is the maximum mortgage loan-to-value ratio. Recall that $q_0 < 0$ holds when borrowing occurs, so that (24) implies that the mortgage amount, $-q_0$, is less than or equal to αh.

To isolate q_0, total investment is written $I = q_0 + \tilde{I}$, where $\tilde{I} = (1 - s)h + \sum_{i=1}^{m} q_i$ is investment in risky assets. Reposing the first-stage problem from Section 2.2., efficient portfolios are now chosen conditional on both h and q_0, yielding a fixed-h/fixed-q_0 efficiency locus. Expected portfolio return along this locus is given by the expression $\bar{R}(h, q_0, \tilde{I}, \sigma)$. The second-stage problem is now to choose h_c, h, $\tilde{I}$, q_0, and σ to maximize

$$U(w - q_0 - \tilde{I} - sh_c,\ h_c) + \delta \int V[\bar{R}(h,\ q_0,\ \tilde{I},\ \sigma) + \sigma z + y]\phi(z)dz \tag{25}$$

subject to (24) and the investment constraint.

Suppose the investment constraint is nonbinding but that the collateral constraint binds. Then, by manipulating the first-order conditions of the above problem, it can be shown that $\partial\bar{R}/\partial h < 0$ once again holds. Thus, as before, housing investment is pushed beyond the level that would maximize the portfolio return for given I. This time, the consumer distorts the mix of risky assets not to secure consumption benefits, but rather to loosen the collateral constraint and enlarge the volume of risky investment. In addition,

$$\frac{\partial\bar{R}}{\partial\tilde{I}} > \frac{\partial\bar{R}}{\partial q_0} = r_0 \tag{26}$$

indicating that investment in risky assets ($\tilde{I}$) is not pushed to the point where the expected return to an extra dollar equals the riskless return. The reason is that the extra dollar must be acquired by enlarging the mortgage loan, which requires a portfolio-distorting increase in h. At the optimum, the loss from this distortion must balance the gain, so that

$$\alpha\left(\frac{\partial\bar{R}}{\partial\tilde{I}} - r_0\right) = -\frac{\partial\bar{R}}{\partial h} \tag{27}$$

The right-hand side captures the effect of the distortion, while the left-hand side is the net gain from investing the loan proceeds, which equals α times the excess of $\partial\bar{R}/\partial\tilde{I}$ over the cost of funds.

This analysis may have limited relevance for most established homeowners. The reason is that the desire to invest in risky assets is seldom strong enough to push mortgage borrowing to its maximal level, making the collateral constraint nonbinding. The investment constraint, which is instead binding for most homeowners, thus is a more likely source of portfolio distortion.

By contrast, the collateral constraint often binds for first-time home buyers. Unlike in the above analysis, however, the first-time buyer uses the maximal mortgage not to finance nonhousing investment (which is set at zero), but rather to support consumption expenditure. Since the portfolio is degenerate in this case, consisting of a single risky asset, the above conclusions about portfolio distortion, which apply to the mix of risky assets, do not apply.

3.2. Rental and Owner-occupied Housing as Distinct Assets

A key assumption in the model is that rental and owner-occupied housing are indistinguishable as assets. If instead each type of housing represents a distinct asset, then the previous investment constraint must hold as an equality for all homeowners. As a result, the portfolios of *all* homeowners are distorted, regardless of whether or not they own rental property.

Since little evidence exists comparing the asset returns for owner-occupied and rental housing, it is difficult to know whether these housing types are properly treated as distinct assets. In developing an empirical test of the model in the next section, the assumption that the assets are indistinguishable, which seems defensible as an approximation, is maintained.

4. Empirical Implications

4.1. Predictions of the Theory

Since inefficiency of a homeowner's portfolio is hard to discern empirically, a direct test of the model's predictions would appear to be infeasible. However, an indirect test is possible, as follows. The idea is to compare the portfolios of two different homeowners, both of whom undertake the same total investment I and invest the same amount h in housing. The individuals differ in the amount of housing consumed, with $h_c = h$ holding for one homeowner and $h_c < h$ holding for the other, indicating ownership of rental property.

Figure 4 illustrates the solutions for the two homeowners, on the assumption that the investment constraint is binding for the individual with $h_c = h$. The solution for the homeowner with $h_c < h$, whose portfolio is undistorted, lies at the point of tangency between the relevant fixed-h locus and the efficient line, shown as point C in figure 4. Because h and I are held constant, Proposition 1 implies that the solution for the individual with $h_c = h$ lies downhill from C *on the same fixed-h locus*, at a point like D. As can be seen, portfolio expected return and risk are both lower at D than at C. This risk-return difference reflects a difference in the underlying mix of nonhousing assets, which varies

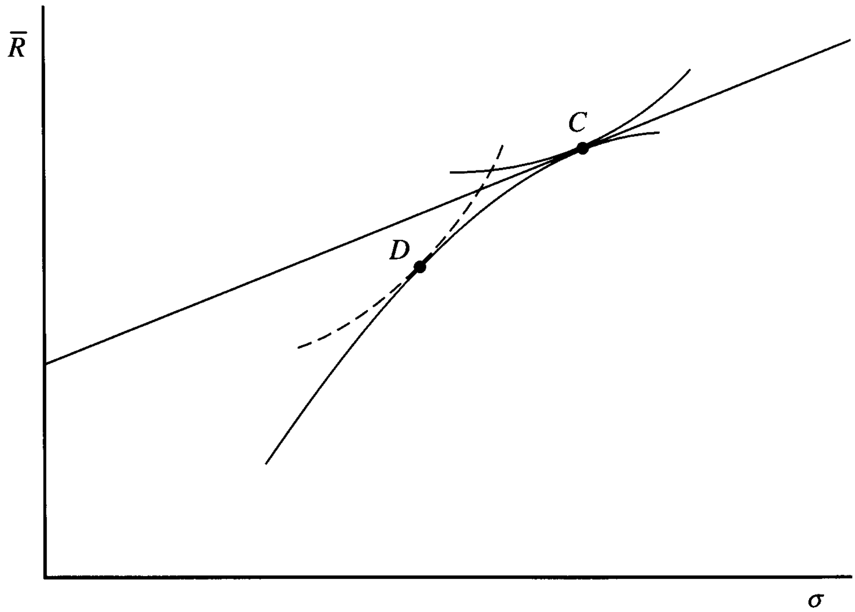

Figure 4. Binding vs. nonbinding solutions with the same h.

along a fixed-h locus. It is important to note that for h_c to differ between the homeowners as assumed while h and I are the same, the risk-return indifference curves must be flatter for the individual who owns rental property (see figure 4). Summarizing yields[17]

Proposition 2. Consider two homeowners with the same total investment I and investment in housing h. One consumes all of his housing investment $(h_c = h)$, and the other owns rental property and thus consumes less than his investment $(h_c < h)$. The mix of nonhousing assets differs between these individuals, and both expected portfolio return $\bar{R}$ and risk σ are higher for the second individual.

4.2. Empirical Evidence

Testing the second part of Proposition 2, which predicts a portfolio-return difference between the binding and nonbinding cases, is not feasible because existing data sets do not allow the computation of $\bar{R}$. The problem is that, while interest and dividend income and realized capital gains are available, unrealized gains (computed on a yearly basis) are not reported.[18] As a result, a test of the proposition must focus on the first part, which predicts an asset-mix difference between the binding and nonbinding cases. In constructing a test, it must be recognized that the theory cannot predict exactly how the nonhousing asset mix differs between points like C and D in figure 4. The approach will thus test for a mix difference between the binding and nonbinding cases with no prior expectations about its nature.

The test is carried out as follows. Data from the 1983 *Survey of Consumer Finances* are used to construct the variables I and h for a sample of homeowners, along with a dummy variable RENTPROP, which assumes the value one if the individual's h includes rental property. Nonhousing assets are divided into three categories: liquid assets (LIQASSET), other financial assets (FINASSET), and other nonhousing assets (OTHASSET), as explained further below. To test for the expected asset-mix difference, each of these variables is regressed on the I and h measures, RENTPROP, and some additional variables, yielding three separate asset equations. The presence of I and h in these equations follows Proposition 2, which holds I and h fixed. In addition, the RENTPROP variable distinguishes being the binding and nonbinding cases, which correspond to values of zero and one. Thus, rejecting the null hypothesis that the asset mix is the same in the binding and nonbinding cases, holding I and h fixed, means rejecting the hypothesis that the RENTPROP coefficient equals zero in each of the three equations.

The additional right-hand variables are meant to control for differences in the pattern of investment returns across the sample. Since housing returns and purchase prices vary geographically, state dummy variables are included along with additional dummies indicating whether the household resides in a large SMSA central city, large SMSA suburb, small SMSA central city, or small SMSA suburb. The household's marginal tax rate (MTXRATE), which may affect the choice between taxable and tax-exempt investments, also appears as a right-hand variable.[19]

The h measure, denoted HOUSVTOT, equals the value of the principal residence plus the value of any seasonal homes plus the value of rental property owned by the household. I is represented by the household's net worth (NETWORTH), which is computed exclusive of the value of non-thrift pensions.[20] Referring to (5), this choice ignores the fact that I equals net worth (h plus other assets less riskless borrowing) minus sh, the sum of actual and imputed rent. However, since h already appears in the equation, and since rent variation is captured by the location variables, the regression should adequately control for variation in I and h across the sample. LIQASSET equals the sum of checking, money-market, and savings accounts, IRA and Keogh accounts, certificates of deposit, and savings bonds. FINASSET equals the value of bonds, stocks, mutual funds, and trusts. OTHASSET includes thrift-type pension accounts, whole life insurance, vehicles, and other miscellaneous nonhousing assets.

Table 1 shows variable means, including the value for total debt (DEBT), which is not used in the regressions. Observe that the sum of the three asset variables plus HOUSVTOT minus DEBT equals NETWORTH. Also, note that just 7% of the 1890 households in the sample own rental property.[21]

Ideally, estimation of the three asset equations should account for the endogeneity of NETWORTH, HOUSVTOT, and RENTPROP. Initially, however, these variables are treated as exogenous, and the equations are estimated by the method of seemingly unrelated regressions (SUR). Because the same right-hand variables appear in each equation, the SUR parameter estimates are the same as those from OLS. However, since the error correlation between equations must be taken into account in testing the joint restriction of zero RENT PROP coefficients, SUR is the proper estimation method.

The estimates are shown in the top half of table 2, which does not report the intercepts or

Table 1. Variable means.

Variable	Mean
LIQASSET	$14,397
FINASSET	8,943
OTHASSET	18,360
HOUSVTOT	62,645
DEBT	20,017
NETWORTH	84,328
RENTPROP	0.073
MTXRATE	17.6

Observations = 1890.

Table 2. Estimation results.*

	Seemingly unrelated regression results Independent variables			
Dependent variable	NETWORTH	HOUSVTOT	RENTPROP	MTXRATE
LIQASSET	0.2047	−0.1949	3528.6	82.300
	(30.20)	(−15.58)	(1.28)	(1.40)
FINASSET	0.5244	−0.4936	4584.5	278.12
	(55.33)	(−28.22)	(1.19)	(3.38)
OTHASSET	0.1646	0.2037	−21057	199.48
	(16.77)	(11.25)	(−5.26)	(2.34)

F-statistic for test of zero RENTPROP coefficients = 13.38.

	3SLS Regression results Independent variables			
Dependent variable	NETWORTH	HOUSVTOT	RENTPROP	MTXRATE
LIQASSET	0.3195	−0.1446	−33782	−201.42
	(10.23)	(−1.32)	(−1.13)	(−1.74)
FINASSET	0.3424	−0.3151	−10282	517.72
	(8.40)	(−2.20)	(−0.26)	(3.43)
OTHASSET	0.1410	0.1189	−11663	373.27
	(3.62)	(0.87)	(−0.31)	(2.58)

F-statistic for test of zero RENTPROP coefficients = 0.49.

* *t*-statistics in parentheses; intercepts and location-variable coefficients not reported.

location-variable coefficients.[22] As can be seen, investment in the each of three asset categories rises with NETWORTH, a natural finding. In addition, an increase in HOUSVTOT raises OTHASSET, while LIQASSET and FINASSET are both decreasing in HOUSVTOT. The MTXRATE coefficients show that for given NETWORTH and HOUSVTOT, an increase in the marginal tax rate leads to an increase in FINASSET and OTHASSET (the LIQASSET equation has an insignificant coefficient).

The RENTPROP dummy has statistically insignificant effects on LIQASSET and FINASSET. However, OTHASSET declines significantly when rental property is owned. The estimated coefficient in the OTHASSET equation shows that other nonhousing assets are on average \$21,000 lower when the portfolio includes rental property. While this result is suggestive, evaluating the maintained hypothesis requires a joint test on all three RENTPROP coefficients. As seen in the table, the F-statistic for this test equals 13.38, which is well above the 5% critical value of approximately 2.6. Therefore, based on the SUR results, the hypothesis of Proposition 2 appears to be confirmed: the mix of nonhousing assets differs between the binding and nonbinding cases, holding I and h fixed.

To correct for endogeneity of NETWORTH, HOUSVTOT, and RENTPROP, these variables can be replaced by fitted values from first-stage regressions. While fitted values for RENTPROP ideally would be generated from a probit model, this would complicate the computation of coefficient standard errors and create difficulties in computing a statistic for the joint test on the RENTPROP coefficients. As a result, fitted values for RENTPROP are computed from a linear probability model.[23] This means that the equation system can be estimated by three-stage least squares, which leads directly to an F-statistic for the joint test. The instruments in the estimation are MTXRATE, the location variables, a variety of demographic variables (age, sex, education, marital status, health, race, and years of full-time work for the household head; household size), and a number of variables affecting financial decisions (wage income, attitudes toward borrowing and risk, preference for liquidity, receipt (or expected receipt) of an inheritance).

The 3SLS results are shown in the bottom half of table 2. Notable changes are declines in the t-statistics for the HOUSVTOT coefficients, which leave only one significant case, and the insignificance of all the RENTPROP coefficients. The latter change is reflected in a much lower F-statistic value for the joint test (0.49), which does not allow rejection of the hypothesis that all the RENTPROP coefficients are zero.

In appraising these results, it should be noted that the fit of the reduced-form equations is not good, leading to a poor correspondence between the fitted and actual values of the variables. The R^2 values for the NETWORTH and HOUSVTOT equations are 0.28 and 0.25, respectively, and the R^2 for the RENTPROP equation is 0.07, a low value that is consistent with the dichotomous nature of the variable. Thus, the 3SLS results, which do not conform to expectations, may be due to the relatively poor fit of the reduced-form equations. Alternatively, despite the favorable SUR results, the 3SLS estimates could indicate the falsity of the hypothesis that the nonhousing asset mix differs between the binding and nonbinding cases. The upshot is that the empirical evidence appears to be inconclusive, and that further investigation using other data sets is warranted. In any case, the previous discussion illustrates the type of empirical strategy that may be used to test the model.

5. Conclusion

This article has investigated the portfolio choices of homeowners, taking into account the investment constraint introduced by Henderson and Ioannides (1983). The main conclusion of the article is that when the constraint is binding, the optimal portfolio of the homeowner is inefficient in a mean-variance sense, reflecting overinvestment in housing. This outcome is not an indication that homeowners are irrational or careless in their financial decisions. Instead, portfolio inefficiency can be seen as the result of a rational balancing of the consumption benefits and portfolio distortion associated with housing investment.

While couched in terms of housing, the analysis applies to portfolio choice involving any asset that yields consumption benefits (such as art or jewelry). The article therefore fills a gap in the literature of portfolio theory, which has ignored the effect of consumption motives in the acquisition of such assets.

The article also highlights the potential benefits of an institutional change that would allow individuals to be partial owners of the houses that they occupy. Such an arrangement would remove the investment constraint from the consumer choice problem, and would eliminate the portfolio inefficiency that it creates. In a recent article, Caplin, Freeman, and Tracy (1994) present a cogent and detailed proposal for a ''housing partnership'' scheme, where a owner-occupier's house would be partly owned by a ''limited partner.'' Given the present analysis, such a scheme could generate substantial benefits.

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Appendix

Letting λ and μ denote multipliers, the Lagrangian expression for the conditional portfolio-choice problem is

$$\bar{r}_h h + r_0 q_0 + \sum_{i=1}^{m} \bar{r}_i q_i - \lambda\left[\left(\theta_{hh} h^2 + 2\sum_{i=1}^{m} h q_i \theta_{hi} + \sum_{i=1}^{m}\sum_{j=1}^{m} q_i q_j \theta_{ij}\right)^{1/2} - \sigma\right] - \mu\left[(1-s)h + \sum_{i=0}^{m} q_i - \mathrm{I}\right] \tag{A1}$$

Assuming interior solutions, the first-order conditions for choice of the riskless and risky nonhousing assets are, respectively,

$$r_0 - \mu = 0 \tag{A2}$$

$$\bar{r}_j - \lambda\left(h\theta_{hj} + \sum_{i=1}^{m} q_i\theta_{ij}\right)\sigma^{-1} - \mu = 0 \quad j = 1, 2, \ldots, m \tag{A3}$$

To establish (12), first multiply (A3) by q_j and sum over j to get

$$\sum_{j=1}^{m} \bar{r}_j q_j - \lambda\left(\sum_{j=1}^{m} hq_j\,\theta_{hj} + \sum_{i=1}^{m}\sum_{j=1}^{m} q_i q_j \theta_{ij}\right)\sigma^{-1} - r_0 \sum_{j=1}^{m} q_j = 0 \tag{A4}$$

Then, suppose that $\partial\bar{R}/\partial h < 0$. Applying the envelope theorem to (A1), this means

$$\frac{\partial\bar{R}}{\partial h} = \bar{r}_h - \lambda\left(h\theta_{hh} + \sum_{i=1}^{m} q_i\theta_{hi}\right)\sigma^{-1} - (1-s)r_0 < 0 \tag{A5}$$

Multiplying (A5) by h and adding the result to (A4), it follows that

$$\bar{r}_h h + \sum_{i=1}^{m} \bar{r}_i q_i - r_0\left[(1-s)h + \sum_{i=1}^{m} q_i\right] - \lambda\sigma < 0 \tag{A6}$$

To reach (A6), note that the terms multiplying λ in (A4) and (A5) (after multiplication by h) sum to σ^2. Substituting from (5) and (7), (A6) can be rewritten

$$\frac{\bar{R} - r_0 I}{\sigma} < \lambda \tag{A7}$$

To interpret (A7), observe that λ equals the slope of the efficiency locus, $\partial\bar{R}/\partial\sigma$, by the envelope theorem. Then observe that the left-hand side of (A7) is the slope of the line segment connecting the efficiency locus to the vertical intercept of the efficient line. Equation (A7) indicates that this line segment is flatter than the locus itself. Given concavity of the locus, it follows that the line segment meets the locus below the point of tangency with the efficient line, as seen in figure 5. Thus, $\partial\bar{R}(h, I, \sigma)/\partial h < 0$ implies $\sigma < \hat{\sigma}(h)$. Reversing the sign of (A5) reverses both of the previous inequalities, establishing (12).

As a final point, observe that another application of the envelope theorem to (A1) yields $\partial\bar{R}/\partial I = r_0$.

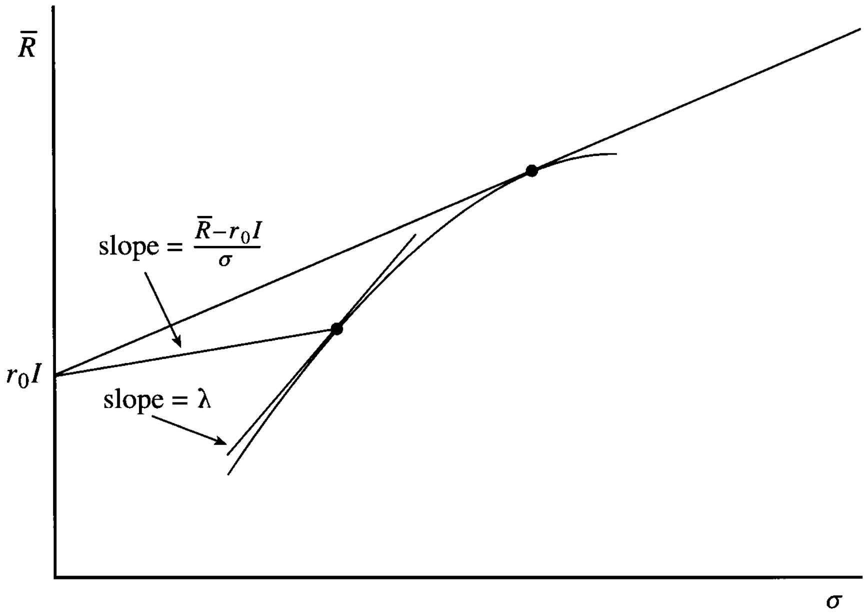

Figure 5. Proof of equation (12).

Notes

1. See Ranney (1981), Schwab (1982), Henderson and Ioannides (1983), Wheaton (1985), Bosch, Morris, and Wyatt (1986), and Poterba (1984).
2. Grossman and Laroque (1990) present a portfolio model very different from the one analyzed here. In their framework, which is developed in continuous time, the housing asset is the only consumption good, and transaction costs prevent frequent adjustment of its level. In contrast to the present case, consumers in their model choose efficient portfolios.
3. With equity sharing, an investor helps the homebuyer make a down payment in return for a share of the house's appreciation. Note also that the investment constraint may not be relevant in a world where individuals occupy several houses (including vacation homes). In this case, h_c could be interpreted as a sum of consumption levels across houses. Then, $h < h_c$ is not ruled out, but indicates that a vacation home is rented rather than owned. This possibility is ignored as unrepresentative of the situation of a typical homeowner, for whom vacation property does not contribute significantly to h_c.
4. Note that this may involve renting out less space in an owner-occupied home.
5. Housing consumption and investment motives play a role in the computable general equilibrium models of Berkovec and Fullerton (1992) and Hendershott and Won (1992). In Berkovec and Fullerton's analysis, homeowners choose h, taking both consumption and portfolio effects into account, although the resulting distortion of the portfolio is not analyzed. In Hendershott and Won's model, consumption and investment demands for housing turn out to be identical, implying that no portfolio distortion exists.
6. In contrast to the above assumptions, the Henderson–Ioannides model includes no risky assets other than housing.
7. Note that sh is the sum of actual and imputed rental incomes, $s(h - h_c)$ and sh_c, both of which are after-tax.
8. Fix σ at $\sigma'' > \hat{\sigma}(h')$ (σ'' is not shown). Then, observe that as long as $\hat{\sigma}(h)$ remains below σ'', higher h values (which again lead to tangencies farther to the right) lead to successively higher efficiency loci at σ''. When h has risen enough that $\hat{\sigma}(h)$ lies above σ,″ the first case again applies.

9. Observe that, since all the $\bar{R}$ derivatives in (16)–(18) are independent of z, they may be brought outside the integrals.
10. To tell whether the constraint binds, the following approach is helpful. First, set η equal to zero and solve (18) and (19) along with the other conditions to get values of h and h_c. These values can be viewed as housing investment and consumption ''demands,'' which are determined without regard to the investment constraint. If these values satisfy that constraint, so that $h \geq h_c$, then they solve the choice problem. If the investment and consumption demands violate the constraint, however, then the constraint binds at the solution, which has different values of h and h_c. Thus, for the binding case to emerge, the consumption demand for housing must *exceed* the investment demand.
11. In an ingenious study, Goetzmann (1993) constructed efficiency loci for several different metropolitan areas, computing optimal housing investment based on local information on housing returns (the portfolios did not include the riskless asset). The preceding results show that such loci are not relevant for homeowners for whom the investment constraint is binding.
12. Fu (1991) offered corrections of several of Henderson and Ioannides' derivations.
13. An increase in initial wealth w raises both investment I and disposable income $w - I$, causing both h and h_c to increase. The increase in w thus has an ambiguous effect on the status of the investment constraint. Also, since an increase in s has an ambiguous effect on the marginal utility of income in the initial period, the impact on I, and thus on both h and h_c, is ambiguous.
14. To see the tax argument, ignore depreciation and other costs of operating a house, let t denote the income tax rate, and let $\tilde{s}$ denote the *before-tax* rent per unit of housing ($s \equiv (1-t)\tilde{s}$ is then the after-tax rent). The owner-occupier pays a tax of $t\tilde{s}(h - h_c)$ on rental income, so that his after-tax income is $(1-t)\tilde{s}(h-h_c) = s(h-h_c)$ (no tax is paid on imputed rent $\tilde{s}h_c$). By contrast, the renter pays rent of $\tilde{s}h_c$ and a tax of $t\tilde{s}h$ on income from owned housing. After-tax income, net of rent paid, is thus $(1-t)\tilde{s}h - \tilde{s}h_c = sh - \tilde{s}h_c$. Thus, while the expression $(1-s)h$ appears again as part of I in (5) for the renter, the term sh_c in (4) is replaced by the larger expression $\tilde{s}h_c$.
15. Evidence provided by Ioannides and Rosenthal (1994) shows that, in actuality, few renters own income property. This suggests that the emphasis of the Henderson–Ioannides model, which argues that tenure decisions depend critically on the trade-off between housing overinvestment and higher renter costs, may be misplaced. Reality may instead reflect a situation where higher renter costs dominate the trade-off, making owning the preferred tenure mode for all, but where downpayment constraints prevent some individuals from purchasing housing. For an analysis of the effect of such constraints, see Brueckner (1986).
16. In the binding case, preference differences will also affect the levels of h and I, with further impacts on portfolio structure.
17. Note that the proposition ignores the case where $h = h_c$ holds but the investment constraint is not binding.
18. The 1989 *Survey of Consumer Finances* does have information on unrealized capital gains, but rather than being stated on an annual basis, gains apply to the entire holding period for the security.
19. This variable is computed by using regression coefficients computed by the U.S. Treasury, which relate a household's tax liability to its characteristics. The coefficients generate estimates of adjusted gross income, exemptions, and total itemized deductions, allowing computation of taxable income and hence MTXRATE.
20. Since households indicating ownership of a business are deleted from the sample, NETWORTH has no business component.
21. The mean value of rental property among these households is $91,178.
22. The R^2 values for the OLS versions of the three equations in Table 1 are 0.38, 0.65, and 0.43, respectively.
23. The ranges of the fitted values for RENTPROP turn out to be very similar in the linear and probit cases. In the linear model, the fitted values lie between -0.113 and 0.505, while in the probit model, the values lie between a number very close to zero and 0.660.

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