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Screening Cost of Buying a House**

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Alas, My Home is *My* Castle:
The Excessive Screening Cost of Buying a House

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Abstract

This paper analyzes a model in which housing tenure choice serves as a means of screening households with different utilization rates. If the proportion of low-utilization types is small, there is a separating equilibrium at which tenure choice acts as a screening device: consistent with empirical evidence, low-utilization households buy a house, while high-utilization types rent. Otherwise, there is a pooling equilibrium. The reason why, contrary to standard screening models, a pooling equilibrium possibly exists is indivisibility of home ownership, which makes it a very costly screening device. Introducing partial ownership restores the standard results: non-existence of a pooling equilibrium and possible non-existence of an equilibrium. The same mechanisms are at work in a corporate finance context.

JEL classification: R31, D82

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1 Introduction

“Why ‘the second half of your home may be the worst purchase you will ever make’”.

Subtitle of Caplin et al. (1997).

This paper presents a model of a housing market with asymmetric information, in which housing tenure choice is used as a screening device.

Consider a housing market, where maintenance cost and/or house value are risky and not verifiable, so the landlord carries the risk for a renter-occupied house (see Henderson and Ioannides, 1983, henceforth “HI”, p. 100). The market is populated by risk-neutral investors and two types of risk-averse households, which differ in terms of their utilization rates, which are not observable. Initially, the houses are owned by the investors. Households either rent or buy a house from them. Given their risk-neutrality, investors are willing, in principle, to provide insurance against maintenance cost and house value risk by renting the houses to the households at a fixed rental rate. For the sake of clarity, ignore all other possible rationales for renting versus buying besides risk shifting, such as taxes, transaction costs, differential access to credit markets, and economies of scale in the owning and management of real estate (Benjamin et al., 1998a). If all households rent, the low-risk households pay more than the fair rent, given their true utilization rate, so they have an incentive to reveal their type. Since there are no verifiable differences between different renters or between different homes, the only possible way to accomplish this is to buy a house (at terms which are unattractive to high-utilization households), thereby eschewing the insurance provided by a rental contract.

The equilibrium analysis follows Rothschild and Stiglitz’s (1976, henceforth: “RS”) pioneering analysis of the insurance market. There exists a separating equilibrium, at which low-risk households buy and high-risk households rent at the fair rate calculated on the basis of their true utilization rate, if the proportion of low-utilization households is small. Giving up the insurance provided by a rental contract is less harmful to households with a low utilization rate in this case than accepting a rental contract which is designed for a household with average utilization rate. While there are numerous applications of RS to real estate (briefly reviewed below), to the best of our knowledge, ours is the first such model in which housing tenure choice serves as the screening device.¹ As low-utilization households live in their own house, while high-utilization individuals rent, the sepa-

¹Miceli (1989) applies RS to the rental market and then adds heterogeneous transaction costs (see the literature review below), which gives low-transaction cost low-utilization households an incentive to buy in order to “leave” the separating equilibrium. Tenure choice is not the screening device employed in an RS-type equilibrium, but a means to overcome the resulting screening costs, in this model.

rating equilibrium is consistent with Galster's (1983) observation that the probability of problems like cracks, holes, and broken windows or steps is 10 to 15 percent lower for owner-occupied than for renter-occupied single family homes and with Shilling et al.'s (1991) finding that tenant-occupied single-family housing depreciates 0.5 to 2.5 percent faster than owner-occupied property.²

If, on the other hand, the proportion of low-utilization households is large, the equilibrium is a pooling equilibrium, at which all households rent at the rental rate calculated on the basis of the average utilization rate. Standard screening models, inspired by the pioneering RS model of the insurance market, emphasize the the general non-existence of a pooling (Nash) equilibrium.³ The root cause of the possible existence of a pooling equilibrium in our model is the indivisibility of house ownership: while insurance coverage and the amount of collateral for a loan are variable, "the current housing market has a major indivisibility because one can not own only part of a house" (Caplin et al., 1997, p. 85). This "major indivisibility" plays a decisive role in the theory of portfolio choice with housing (see Grossman and Laroque, 1990, and the subsequent literature). The argument is related, in a way explained below, to equilibrium in the insurance market with a single insurance contract (see Bolton and Dewatripont, 2005, p. 603).

To shed further light on the impact of indivisibility of home ownership, we introduce partial ownership to the model. There is positive demand for partial ownership, because it is a cheaper way to reveal their type for low-utilization holds than a complete purchase. Allowing for arbitrary proportions of ownership takes us all the way back to the standard RS results: a pooling equilibrium does not exist; a separating equilibrium, at which high-utilization households rent and low-utilization households own part of the house they live in, exists if high-utilization types are sufficiently frequent. Some partial ownership programs exist in practice, mostly publicly-supported programs in Anglo-Saxon countries aimed at increasing affordability (see Davis, 2006, for the U.S. and Whitehead and Yates, 2010, for the U.K. and Australia). Caplin et al. (1997) make a proposal how to advance partial ownership ("housing partnerships") in order to avoid the strong concentration on housing in households' asset portfolio. Caplin et al.'s (2008) shared appreciation mortgages (SAM) proposal is a step in the same direction, employing partial ownership as a means of reducing financial distress in times of crises. Yet, given that partial ownership is the exception from the general

²Gatzlaff et al. (1998) report a difference in appreciation between owner-occupied and renter-occupied houses of only 0.16 percent per annum. Malpezzi et al. (1987) find that the depreciation rate for owner-occupied property falls below that for renter-occupied property only after several years of use.

³Bester (1985) shows that collateral requirements can be used as a screening device in the loan market, thereby helping to avoid credit rationing (cf. Stiglitz and Weiss, 1981; Arnold and Riley, 2009). Riley (2001, pp. 438 ff.) shows how RS-style screening works in the labor market. Applications to real estate are briefly reviewed below.

indivisibility rule, this does not seriously invalidate the conclusion drawn from our baseline model that equilibrium pooling cannot be ruled out.

While the analysis is cast in the context of residential housing, it can be reinterpreted as a model of commercial real estate and also has a straightforward application to corporate finance.

Our model makes a contribution to the literature on housing tenure choice in the presence of asymmetric information (see Hubert, 2006). This literature is inspired by HI, who emphasize the “fundamental rental externality” (p. 99; or “asset abuse problem”, Benjamin et al., 1998a, p. 224) that occurs if the degree of utilization is chosen by tenants and is not verifiable.⁴ We follow Miceli’s (1989, p. 404) reinterpretation of the HI rental externality as an adverse selection problem, stemming from the fact that different tenants are characterized by different (given) rates of utilization. In Miceli (1989), housing services represent a second verifiable variable, so that different rental contracts specifying the levels of rent and housing services can be used to screen tenants, as in RS. Several related papers propose other rental contract terms as means of screening tenants with different degrees of utilization, for instance terminability (Hubert, 1995), the provision of security deposits (Benjamin et al., 1998b), and net versus gross leasing (Mooradian and Yang, 2002). A related strand of the housing literature investigates screening in mortgage markets using non-interest contractual terms, such as mortgage points (Chari and Jagannathan, 1989; Stanton and Wallace, 1998), LTV (Brueckner, 2000), and FRM versus ARM (Posey and Yavas, 2001). What distinguishes our model from this industry of screening models is that it employs the seminal RS approach not in the context of screening renters by means of a menu of rental contracts or screening buyers by means of a menu mortgage contracts, but in a setup where housing tenure choice serves as the screening device.

The paper is organized as follows. Section 2 introduces the model. The equilibrium analysis is in Section 3. Section 4 introduces partial ownership. Alternative interpretations of the model are discussed in Section 5. Section 6 concludes.

2 Model

Consider a static model of a residential housing market. There are a large number of households looking for a home and at least as many investors, each of whom initially owns a house. Each

⁴Interestingly, the possibility of a signalling equilibrium is already mentioned by HI (footnote 2, p. 102), who see no basis for the assumption that utilization rates are negatively correlated with signalling costs, however. In our setup, negative correlation between utilization rate and screening cost naturally follows from risk aversion: low-risk households are more willing to give up the insurance provided by a rental contract.

household has to either rent or buy a house from an investor. The only contractual term of a rental contract is the rent paid R ; the only contractual term of a purchase contract is the price paid P . We argue below that there is no scope for using other contractual terms.

The investors are risk-neutral. As usual in the screening literature, they obtain a given level of expected payments, irrespective of whether they offer their house for rent or for sale. The value of these expected payments as of the end of the period is denoted $\bar{\pi}$ (> 0). One possible interpretation is that there are more investors than households, the investors have no bargaining power, and $\bar{\pi}$ is the expected value of an outside option, such as the use of the property for a different purpose than residential housing, possibly after a period of vacancy. Another interpretation is that there are as many investors and households, there is no outside option for investors, so each investor either rents or sells his house, and $\bar{\pi}$ is a measure of their bargaining power in negotiations with households.

The households are subdivided into two classes $j = L, H$. The end-of-period value of a house occupied by a type- j household is V (> 0) with probability $1 - p_j$ and $V - I$ with probability p_j ($0 < I < V$, $0 < p_L < p_H < 1$). I can be thought of as reduction in house value due to wear and tear or as costs of maintenance and repairs. p_j is a measure of type j 's utilization rate. Type-H households have a higher utilization rate than L-types. The probabilities p_L and p_H are exogenous, so there is not an asset abuse problem. However, household type is private information and, therefore, not verifiable. As argued by HI (p. 100), the incidence of a value loss I is not verifiable either: "the marginal costs of increased breakdowns and wear and tear caused by increased rates of utilization cannot be fully charged to the tenant. It is impossible to explicitly provide in rental contracts for all possible contingencies, let alone even collect on all contingencies provided for."⁵

The relative frequency of type-L households is denoted η ($0 < \eta < 1$).

Household utility is a twice continuously differentiable utility function u of final wealth x (≥ 0). Households are risk-averse: $u'(x) > 0 > u''(x)$. Let W (> 0) denote households' initial wealth and i (> 0) the interest rate for funds invested at the beginning of the period. Renters pay the rental rate R at the end of the period. This captures, in our static model, that the flow of rent payments is stretched out over time, while the purchase price P is paid immediately. A type- j household's expected utility is

$$U^r(R) = u((1 + i)W - R) \tag{1}$$

⁵The adverse selection problem vanishes in the same way as the moral hazard problem emphasized by HI and the subsequent literature vanishes if rental contracts can specify payments depending on actual utilization. Notice, however, that a similar problem would arise if actual utilization is private information of the seller in a future resale of the house (Harding et al. 2000).

if it rents and

$$U_j^b(P) = (1 - p_j)u((1 + i)(W - P) + V) + p_ju((1 + i)(W - P) + V - I) \quad (2)$$

if it buys a house. Given that I is not verifiable, households cannot buy insurance against a value loss in the latter case.

The (safe) rental rate at which investors are willing to rent to a household with expected probability p_j of causing a value loss I is

$$R_j = \bar{\pi} - V + p_jI. \quad (3)$$

The higher expected cost for type-H borrowers is reflected in the higher rent they have to pay.⁶ Let $\bar{\pi} > V - p_L I$, so that the rent is positive for $j = L, H$. To buy a house, households have to pay sellers the price \bar{P} such that

$$(1 + i)\bar{P} = \bar{\pi}. \quad (4)$$

Let $c = (1 + i)W - \bar{\pi} + V > I$. This inequality ensures that a household that buys a house at price \bar{P} has non-negative final wealth even if a value loss occurs (see (2)). Agents are personally liable for any repayment obligations.

3 Equilibrium

This section analyzes the equilibrium of the economy described above. In the main text, we use the standard RS graphical approach. Algebraic proofs of the propositions are in the Appendix.

From (1) and (3), a type- j household that pays the rental rate R_k gets safe utility $U^r(R_k) = u(c - p_k I)$. From (2), (4), and the definition of c , the expected utility of a household that buys at price \bar{P} can be written as

$$U_j^b(\bar{P}) = (1 - p_j)u(c) + p_ju(c - I).$$

The analogy to an insurance market is evident.

If information were symmetric, households of type j would rent at the respective fair rate given by (3) and get utility $U^r(R_j) = u(c - p_j I)$. Figure 1 is the standard illustration. The final wealth levels without and with a damage are plotted along the horizontal and vertical axes, respectively. The point $(c, c - I)$, denoted B in Figure 1, depicts the wealth levels for a buyer. The straight line with

⁶There is no tradeoff between price risk and rent risk, as in Sinai and Souleles (2005). If the market were a sellers' market, then house owners would rent their houses to the households and the rental rate would be $R = (1 + i)W - u^{-1}(\bar{U})$ for both types of households (where \bar{U} is their reservation utility). There would be no scope for adverse selection and no need for screening.

slope $-(1-p_L)/p_L$ through that point intersects the 45-degree line at $(c-p_L I, c-p_L I)$. This point, denoted L, represents the certain wealth level with rent at rate R_L . A type-L indifference curve (not depicted in the figure) is tangent to that straight line there. Strict convexity of indifference curves (i.e., risk aversion) implies that the point $(c, c-I)$ is located below the type-L indifference curve through $(c-p_L I, c-p_L I)$. Analogously, point H represents H-types' first-best wealth levels. Both types prefer rent at the respective fair rate to home ownership.

Turning to asymmetric information, we adopt the RS definition of equilibrium: a set of contracts is an *equilibrium* if, given that each household chooses a contract which yields maximum utility, each investor gets expected payments worth $\bar{\pi}$ and there is no contract outside the set which allows an investor to get a higher level of utility when the other investors maintain their offers. An equilibrium is a *pooling equilibrium (PE)* if all households choose the same contract. An equilibrium is a *separating equilibrium (SE)* if households of the two different types choose different contracts. As said above, rental and purchase contracts are fully characterized by R and P , respectively.

Let $p_M = \eta p_L + (1-\eta)p_H$ denote the average probability that the value reduction I happens, and let R_M be the rent level that yields investors expected income $\bar{\pi}$ when they offer a rent contract accepted by both types of households (i.e., (3) with $j = M$).

Proposition 1: *Equilibrium exists and is (generically) unique. There is $\tilde{\eta}$ ($0 \leq \tilde{\eta} < 1$) such that for $\eta < \tilde{\eta}$, the rent contract with rental rate R_H and the purchase contract with price \bar{P} are an SE, and for $\eta > \tilde{\eta}$, the rent contract with rental rate R_M is a PE.⁷*

Proof: If a household rents at rental rate R_M , its final wealth pair $(c-p_M I, c-p_M I)$ is represented by a point such as M on the 45-degree line in Figure 1. p_M is a continuous function of η and takes on the values $c-p_H I$ for $\eta = 0$ and $c-p_L I$ for $\eta = 1$. So there is $\tilde{\eta}$ in the unit interval such that M coincides with the intersection of the 45-degree line and the L-type indifference curve through $(c, c-I)$, point I say.

Suppose $\eta < \tilde{\eta}$, so that M is located to the left of I (the case depicted in Figure 1). Let a proportion η of the investors offer their houses for sale at price \bar{P} , while the other investors offer rent contracts with rental rate R_H . Type-L households buy, type-H households rent. Investors do not find sellers with a price higher than \bar{P} and do not break even with $P < \bar{P}$. In order to attract L-types and yield income higher than $\bar{\pi}$, a rent contract has to specify a rental rate higher than R_M . But L-types do not select such a contract. So there is an SE with rent at rate R_H and sales at price \bar{P} .

Next, suppose $\eta > \tilde{\eta}$, so that (contrary to Figure 1) $(c-p_M I, c-p_M I)$ is located to the right of

⁷To save space, the assertion of the proposition does not cover the (non-generic) case $\eta = \tilde{\eta}$. Analogous remarks apply to the subsequent propositions.

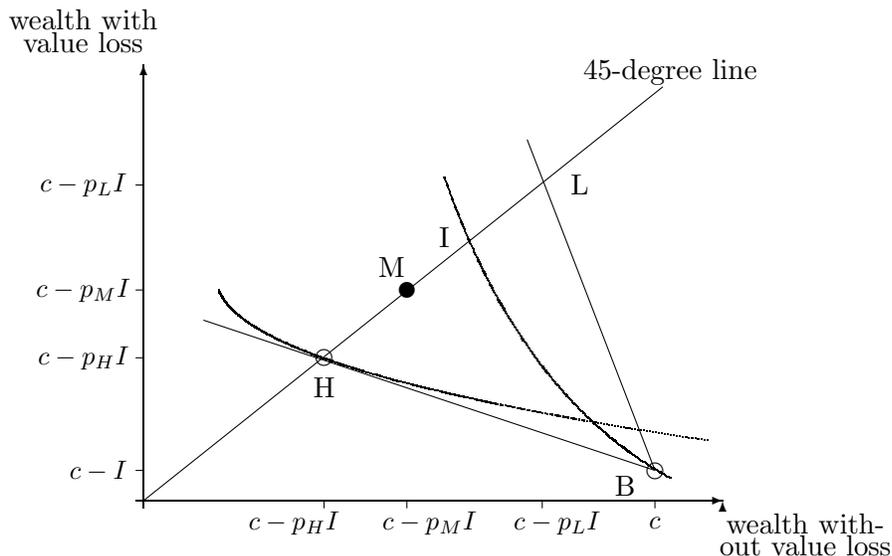


Figure 1: Equilibrium with indivisible ownership

I. Let all investors offer their houses for rent at R_M . Since there are no houses for sale, any lower rental rate attracts both types but yields less than $\bar{\pi}$; higher rates imply zero demand. Likewise, there is no demand for houses at a price equal to or greater than \bar{P} , and any price below \bar{P} is not sufficient to achieve expected income $\bar{\pi}$. So the rent contract with rate R_M is a PE.

If $\eta < \tilde{\eta}$, there is not a PE, since L-types prefer buying at a price slightly above \bar{P} to rent at R_M . If $\eta > \tilde{\eta}$, there is not an SE, for if L-types buy at \bar{P} and H-types rent at R_H , a rent contract with rental rate slightly above R_M raises investors' expected utility. This proves uniqueness. \parallel

Housing tenure choice is the screening device in an SE: if there are few L-types (η is small), they prefer to buy, since the pooling rent R_M is much higher than the fair rent R_L . Self-selection implies that a value loss is less likely for a owner-occupied house (bought by an L-type) than for a renter-occupied house (rented by an H-type). The model thus provides an explanation for the correlations observed by Galster (1983) and Shilling et al. (1991) which is based on adverse selection, rather than the HI moral hazard problem.

In the RS model of the insurance market, with variable degree of coverage, a PE generally does not exist, and an equilibrium fails to exist at all if the proportion of low-risk individuals is sufficiently large. By contrast, Proposition 1 establishes existence of equilibrium, and the equilibrium entails pooling if the proportion of low-utilization households is high. An analogous result obtains in the insurance market if one allows for only one contract (see Bolton and Dewatripont, 2005, 603). The choice between the single insurance contract and no insurance in that model is analogous to the

rent-or-buy decision in our model. Note, however, that we do not rule out multiple contracts by assumption: households have to sign a purchase contract if they do not rent, and the definition of equilibrium entails that investors try to make a profit with whichever contract serves this purpose. The pooling rent contract emerges from a multitude of possible rent and purchase contracts as the only contract that survives in competition. Naturally, allowing for only a single contract hardly receives attention as a solution to the non-existence problem in the insurance literature (see Riley, 2001, 447 ff.);⁸ given the common use of limited coverage and deductibles, there is no point in restricting attention to contracts which provide full coverage. By contrast, the “major indivisibility” of house ownership in practice provides a sound basis for focussing on complete ownership contracts in the context of residential real estate.

Housing tenure choice is the only screening instrument in our model. There is no scope for using other screening instruments in rental and/or purchase contracts. As for rental contracts, the non-verifiability of I precludes the use of a security deposit with refund contingent on the occurrence of a value loss (Benjamin et al., 1998b) and net leasing (Mooradian and Yang, 2002). Given the static nature of the model, terminability of rental contracts (Hubert, 1995) and ARM (Posey and Yavas, 2001) are not an issue. Allowing for arbitrary levels of LTV (Brueckner, 2000) does not make a difference. One straightforward interpretation of (2) is that households pay the purchase price P cash out of their initial wealth W . An equivalent interpretation is that they use equity E and a mortgage loan of size $P - E$ to pay for the house, so that expected utility is

$$(1 - p_j)u((1 + i)(W - E) + V - (1 + i)(P - E)) \\ + p_ju((1 + i)(W - E) + V - (1 + i)(P - E) - I).$$

Equity E cancels out, and expected utility becomes $(1 - p_j)u(c) + p_ju(c - I)$, as before. Use is made of personal liability, which implies that there is no strategic default if the mortgage is underwater (i.e., when $V - I < (1 + i)(P - E)$). Since buying a house is excessively costly anyway (see the next section), there is no point in using mortgage points which are costly to acquire (Chari and Jagannathan, 1989; Stanton and Wallace, 1998).

Proposition 1 does not rule out $\tilde{\eta} = 0$, in which case the condition for an SE $\eta < \tilde{\eta}$ cannot be satisfied. In fact, the equilibrium is a PE for all η if p_L is sufficiently close to p_H , so that the incentive to reveal their type is weak for L-types. The graphical approach used here does not lend itself well to analyze the effect of changes in p_L , because this affects the location of the curves in Figure 1. So the proof of this assertion is delegated to the Appendix.

⁸The standard solutions entail changes in the definition of equilibrium (e.g., Wilson, 1977) or adding a sequential structure to the contracting game (Hellwig, 1987).

4 The excessive cost of screening

The preceding section has established existence and uniqueness of equilibrium and the possibility of pooling. To show that these results are due to the maintained assumption that house ownership is indivisible, this section shows that introducing partial ownership takes us back to the standard RS results.

Suppose households can buy an arbitrary fraction α ($0 \leq \alpha \leq 1$) of a house at price $P(\alpha)$, which includes a discount compared to the of one-hundred percent ownership transfer if $\alpha < 1$. Partial ownership gives the household the exclusive right to live in the house plus a fraction α of its final value, i.e., V or $V - I$. The cash flows are straightforward to implement if one interprets I as an irrecoverable reduction in value, which materializes if the house is resold. If one interprets I as maintenance costs, the assumption is that the two parties agree that the household bears a fraction α of the costs, once maintenance becomes necessary. This presupposes that, even though I is not contractable, it is observable to investors and households (as in the standard holdup problem; cf. Bolton and Dewatripont, 2005, 562).

As before, the utility of a type- j household that rents a house is given by (1). The expected utility of a type- j buyer is now

$$U_j^b(P(\alpha), \alpha) = (1 - p_j)u((1 + i)(W - P(\alpha)) + \alpha V) + p_j u((1 + i)(W - P(\alpha)) + \alpha(V - I)). \quad (5)$$

The house owners' participation constraint for selling their house to a type- L household says that the sum of the compounded sales price and their share in the expected house value is equal to $\bar{\pi}$:

$$(1 + i)P(\alpha) + (1 - \alpha)(V - p_L I) = \bar{\pi}. \quad (6)$$

Rent and complete purchase are the polar cases with $\alpha = 0$ and $\alpha = 1$, respectively. For $\alpha = 0$, the sales price becomes $P(0) = R_L/(1 + i)$, and, using (3) and (6), buyer expected utility is $U_L^b(P(0), 0) = u(c - p_L I)$. This is analogous to rent at rate $R_L/(1 + i)$ payable at the beginning of the period, which in turn is analogous to rent at rate R_L payable at the end of the period. Setting $\alpha = 1$ takes us back to the analysis in Section 3.

Substituting for $P(\alpha)$ from (6) into (5) gives

$$U_L^b(P(\alpha), \alpha) = (1 - p_L)u(c - (1 - \alpha)p_L I) + p_L u(c - (1 - \alpha)p_L I - \alpha I).$$

Differentiating with respect to α shows that a lower ownership share α yields higher expected utility for L -type buyers:

$$\frac{dU_L^b(P(\alpha), \alpha)}{d\alpha} = p_L(1 - p_L)I [u'(c - (1 - \alpha)p_L I) - u'(c - (1 - \alpha)p_L I - \alpha I)] < 0.$$

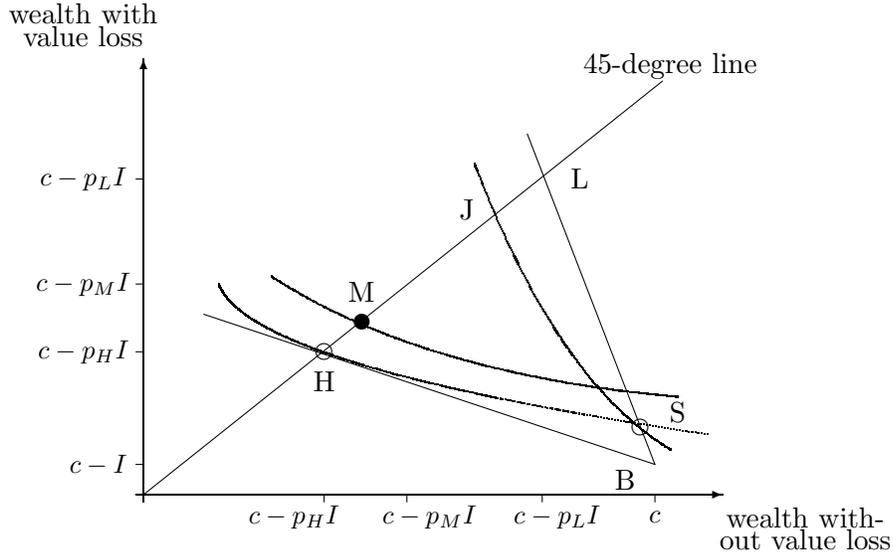


Figure 2: Equilibrium with partial ownership

Hence, type-L households have an interest in partial ownership contracts, because screening is *excessively* costly, in that buying a smaller share of a house, which is still unattractive to H-types, would be enough to reveal their type and cause a lower screening cost in terms of risk bearing. Accordingly, let a purchase contract now be characterized by ownership share α and price $P(\alpha)$. With this modification, equilibrium, SE, and PE are defined as in Section 3.

Proposition 2: *A PE does not exist. There is $\hat{\eta}$ ($0 < \hat{\eta} < 1$) such that an SE exists for $\eta < \hat{\eta}$ and no equilibrium exists for $\eta > \hat{\eta}$.*

Proof: Figure 2 is constructed analogously to Figure 1. The rental contract with rent R_k yields final wealth levels illustrated by the point $(c - p_k I, c - p_k I)$ on the 45-degree line. The ownership contracts with $\alpha = 0$ and $\alpha = 1$ yield wealth levels $(c - p_L I, c - p_L I)$ (point L) and $(c, c - I)$ (point B) respectively. Given the linearity of the final wealth levels as functions of α , partial ownership contracts with α in between zero and one are represented by points on the line segment BL.

There cannot be a pooling equilibrium at which both types acquire ownership, for it would be profitable to insure H-types with a rent contract with R slightly above R_H . Suppose there is a pooling equilibrium at which both types rent at R_M . Then a partial ownership contract which yields wealth levels on the line segment BL slightly below the intersection with the H-type indifference curve through M is strictly preferred to rent at R_M by L-types, so they are willing to pay a price $P > P(\alpha)$ for this contract. Since this contract is not accepted by H-types, it yields expected payments higher than $\bar{\pi}$ for investors, a contradiction.

The only candidate equilibrium is an SE at which H-types get their first-best contract (with wealth levels illustrated by point H in Figure 2) and L-types get their most preferred partial ownership contract consistent with the H-types' self-selection constraint (point S). This pair of contracts is an SE if the pooling rent contract is unattractive for L-types. There is $\hat{\eta}$ in the unit interval such that the intersection point J of L-types' indifference curve through S and the 45-degree line coincides with M. For $\eta < \hat{\eta}$, J is located to the right of M (as depicted in Figure 2), so L-types do not prefer the pooling contract, and there is an SE. For $\eta > \hat{\eta}$, the pooling contract attracts L-types, so an equilibrium does not exist. ||

The similarity to the standard RS arguments is evident. A PE does not exist; an SE exists if bad risks are sufficiently frequent so that pooling is more costly to the good risks than screening. This also sheds new light on why a PE possibly exists without partial ownership: the only way to screen the good risks is to offer them complete ownership of a house, which is more costly for them in terms of risk taking than owning only a fraction. There is not a qualitative difference between rent, partial ownership, and complete ownership in our model, which are parameterizations with α equal to zero, between zero and one, and equal to one, respectively. The crucial point is that ruling out partial ownership restricts the set of feasible α 's to $\{0, 1\}$, which constitutes a severe limitation of screening feasible activities and possibly gives rise to equilibrium pooling.

The next proposition provides a welfare comparison of partial versus complete ownership:

Proposition 3: *In an equilibrium with divisible ownership, type-H households are no worse-off and type-L households are no better-off than with indivisible ownership.*

Proof: Equilibrium with divisible ownership exists for $\eta < \hat{\eta}$. Let $\hat{\alpha}$ denote households' equilibrium ownership share at such an equilibrium. $\hat{\alpha}$ is independent of η . For $\eta = \hat{\eta}$, type-L households are indifferent between owning a fraction $\hat{\alpha}$ of a house and the pooling rent contract. For $\eta = \tilde{\eta}$, they are indifferent between completely owning a house and the pooling rent contract. From the fact that the utility drawn from the pooling rent contract $u(c - p_M I)$ is an increasing function of η , it follows that $\hat{\eta} > \tilde{\eta}$. In terms of Figures 1 and 2, as η rises and point M moves to the right on the 45-degree line, it first coincides with I and then with J.

For all $\eta < \hat{\eta}$, type-L households' equilibrium utility with divisible ownership is $U_L^b(P(\hat{\alpha}), \hat{\alpha})$. For $\eta < \tilde{\eta}$, their equilibrium utility with indivisible ownership $U_L^b(\bar{P})$ is lower because of the excessive cost of screening. For $\tilde{\eta} < \eta < \hat{\eta}$, there is a PE with indivisible ownership, at which L-households obtain equilibrium utility $U^r(R_M)$. $U^r(R_M)$ rises from $U_L^b(\bar{P})$ to $U_L^b(P(\hat{\alpha}), \hat{\alpha})$, as η rises from $\tilde{\eta}$ to $\hat{\eta}$ (since at $\tilde{\eta}$ they are indifferent between rent at R_M and a complete purchase at price \bar{P} , and at $\hat{\eta}$ they are indifferent between rent at R_M and a buying a fraction $\hat{\alpha}$ of a house at $P(\hat{\alpha})$). Hence,

$U^r(R_M)$ does not rise above utility with divisible ownership $U_L^b(P(\hat{\alpha}), \hat{\alpha})$.

With divisible ownership, type-H households' get their first-best rent contract and, hence, utility $U^r(R_H)$ for all $\eta < \hat{\eta}$. For $\eta < \tilde{\eta}$, they get the same contract and, hence, the same utility with indivisible ownership. For $\tilde{\eta} < \eta < \hat{\eta}$, they are pooled with the L-households and obtain utility $U^r(R_M) > U^r(R_H)$. ||

Partial ownership is beneficial to type-L households, irrespective of whether the equilibrium with complete ownership entails pooling or screening. When η is low, there is an SE in both ownership regimes, but the screening cost is lower with partial ownership. For larger values of η , there is pooling when ownership is indivisible. The condition for existence of equilibrium with indivisible ownership is that this entails lower expected utility for type-L households than complete ownership, which in turn falls short of equilibrium expected utility with partial ownership. Equilibria under the two ownership regimes cannot be Pareto-ranked: the best scenario for L-types is a PE with indivisible ownership, since the cross-subsidization by low-utilization households implies that they attain a higher than first-best level of utility.

As η rises beyond $\hat{\eta}$, equilibrium with divisible ownership ceases to exist, and households' utility in the PE with indivisible ownership rises further, up to L-types' first-best level $u(c - p_L I)$.

5 Application to commercial real estate and corporate finance

The model can be reinterpreted as one of commercial real estate if one thinks of the owners as the operators of a shopping center and of the potential buyers as shopkeepers, who decide whether to buy or to lease a shop, which they use more or less intensively, depending on (unalterable) individual characteristics (as in Mooradian and Yang, 2002). No modification of the formal analysis is required. This section shows how minor modifications yield a model of corporate finance.

Consider a set of small start-up firms, which need to invest B in order to get their business going. The value of each firm is V or $V - I$, where I is a non-verifiable negative shock to their profitability. A proportion η of the firms is of type $j = L$ and faces a low probability p_L of a negative profitability shock, the rest is of type $j = H$ and the probability of low profitability is p_H ($> p_L$). Each firm is owned by a single risk-averse entrepreneur with no internal funds, whose type is unobservable. To start his business himself he has to borrow B at interest i . To avoid the issue of bankruptcy, let $V - I > (1 + i)B$. Alternatively, he can sell his firm to risk-neutral investors, who then provide the required capital B and run the firm.

In the case of debt finance, a firm owner of type j has expected utility

$$U_j^d = (1 - p_j)u(V - (1 + i)B) + p_j u(V - (1 + i)B - I).$$

As in the housing model of Section 2, consider first the case in which only a complete sale is possible. The utility of an entrepreneur who sells his firm at price P is

$$U^s(P) = u((1 + i)P).$$

The price P_k investors are willing to pay for a firm with expected probability p_k of a negative profitability shock is given by

$$(1 + i)P_k = V - p_k I - (1 + i)B. \quad (7)$$

Given their risk aversion, the first-best solution entails that firm owners sell their businesses at the respective fair price P_L or P_H .

Define (differently than before) $c = V - (1 + i)B$. Then $U_j^d = U_j^b(\bar{P})$ and $U^s(P_k) = U^r(R_k)$, and the equilibrium analysis in Section 3 applies. If the entrepreneur runs his leveraged firm, his final wealth pair $(c, c - I)$ is given by point B in Figure 1. The wealth levels resulting from a sale at price P_M or P_L are given by M and L, respectively. For η small enough such that the L-type indifference curve through $(c, c - I)$ intersects the 45-degree line to the left of M, there is an SE at which risky entrepreneurs sell their firm at price P_H and safe entrepreneurs run their business on their own. To induce L-types to also sell their firm, investors would have to offer them a price that yields final wealth higher than at point I in Figure 1. But such an offer is unprofitable, since it is also accepted by H-types and it is higher than the fair price for a randomly chosen firm. For η large enough so that M is to the right of I, there is a PE, at which all entrepreneurs sell their firm at the price P_M . Next, suppose the entrepreneurs can keep an arbitrary share α in their firm and sell the rest. If a j -type entrepreneur gets P for a share $1 - \alpha$ in his business, his expected utility is

$$U_j^s(P, \alpha) = (1 - p_j)u((1 + i)P + \alpha(V - (1 + i)B)) + p_j u((1 + i)P + \alpha(V - (1 + i)B)).$$

Investors are willing to pay the fair price $P_k(\alpha)$ determined by

$$(1 + i)P_k(\alpha) = (1 - \alpha)(V - (1 + i)B - p_k I)$$

for a firm with probability p_k of a negative productivity shock. The resulting expected utility for a type- j entrepreneur is

$$U_j^s(P_k(\alpha), \alpha) = (1 - p_j)u(c - (1 - \alpha)p_k I) + p_j u(c - (1 - \alpha)p_k I - \alpha I).$$

A complete sale (i.e., $\alpha = 0$) yields certain wealth $c - p_k I$. $\alpha = 1$ corresponds to pure debt finance, with final wealth levels given by $(c, c - I)$. In between these polar cases, the relation between the wealth levels in the good and bad states is linear. In terms of Figure 2, the sets of wealth levels resulting from different α 's are represented by the rays from B through L, M, and H, respectively, depending on whether the sales price $P_k(\alpha)$ is calculated using probability p_L , p_M , or p_H . Since the two types' indifference curves intersect on BM, there is not a PE. For wealth levels on BM, it is possible to design a contract with higher α and higher price P that is accepted only by L-types and gives investors expected utility higher than $\bar{\pi}$ (in the "triangle" formed by the two indifference curves and BL). An SE, at which H-types sell their business completely and α is consistent with their self-selection constraint, exists if η is sufficiently small so that the L-types' indifference curve through S intersects the 45-degree line to the right of M. To sum up:

Proposition 4: *With indivisible corporate ownership, there is an SE for η small enough and a PE otherwise. With divisible ownership, a PE does not exist, and an SE exists for η small enough.*

In an SE, high-risk firms sell their business completely, while low-risk firms do not sell (with indivisible ownership) or sell less than one-hundred percent (with perfect divisibility of shares). This is roughly consistent with poor IPO performance (e.g., Loughran and Ritter, 1995). Contrary to residential real estate, financial innovation (viz., the invention of the joint-stock company) has overcome indivisibility of ownership in corporations more than four-hundred years ago, so that, of course, indivisibility is now the exception rather than the rule. The small shopkeeper mentioned at the outset or small family-owned firms may serve as examples of businesses for which transaction costs (not present in the model) prevent partial ownership. Yet, if and where indivisibility holds, the same market forces which induce tenants to buy a house despite the ensuing risks make small entrepreneurs run their risky business on their own.

6 Conclusion

This paper sets up a simple model of screening via housing tenure choice. It provides an explanation for the observed correlation between tenure and depreciation based on indivisibility of house ownership and allows for equilibrium pooling.

To focus on the rent-own decision, the model rules out any verifiable differences between different households as well as between different houses. One direction for future research is to introduce other contractual terms used in the literature and other dimensions of unobserved heterogeneity (cf. Crocker and Snow, 2011). We guess that if the number of hidden characteristics exceeds the

number of contractable variables, the rent-own decision remains part of the screening process.

The model investigates the consequences of indivisibility of ownership, not its causes. In spite of the wide agreement that individuals' asset portfolios are way too strongly concentrated on housing and despite practical proposals how to ameliorate this problem, partial ownership remains an exception from the general rule. Our model reinforces the question why, as it points to another factor that leads to positive demand for partial ownership., viz., reducing the cost of screening for low-utilization households. Maybe it all comes down to people's desire to live in their own four walls. But it is also conceivable that there is an explanation that relies on information problems and can be addressed in an extended version of our model.

Appendix

This appendix provides algebraic proofs of Propositions 1 and 2.

Proposition 1: Consider first an SE. j -types prefer a purchase at \bar{P} to rent at R_k exactly if

$$(1 - p_j)u(c) + p_ju(c - I) \geq u(c - p_kI) \quad (\text{A.1})$$

holds for $k = H$. For $j = L$, the left-hand side is a continuous function of p_L , which falls from $u(c)$ to $(1 - p_H)u(c) + p_Hu(c - I)$ as p_L rises from zero to p_H . So there is \tilde{p}_L (independent of η) in the interval $(0, p_H)$ such that (A.1) holds for $j = L$ and $k = H$ exactly if $p_L \leq \tilde{p}_L$. By Jensen's inequality, (A.1) is violated for $j = H$, so H-types rent. As argued in the main text, an SE prevails if the rental contract with rent R_M does not attract L-types, i.e., if (A.1) holds for $j = L$ and $k = M$. Given $p_M = \eta p_L + (1 - \eta)p_H$, the right-hand side of (A.1) is a continuous function of η , which rises from $u(c - p_HI)$ to $u(c - p_LI)$ as η rises from zero to unity. The necessary condition for an SE $p_L \leq \tilde{p}_L$ and Jensen's inequality imply that the left-hand side of (A.1) with $j = L$ is greater than $u(c - p_HI)$ but less than $u(c - p_LI)$, respectively. So for each p_L , there exists $f(p_L)$ such that (A.1) holds for $j = L$ and $k = M$ exactly if $\eta \leq f(p_L)$. In sum, an SE exists exactly if $p_L \leq \tilde{p}_L$ and $\eta \leq f(p_L)$.

In order for a PE to exist, the weak inequality in (A.1) has to be reversed for $j = L$ and $k = M$. As seen in the preceding paragraph, this condition is satisfied if $p_L \leq \tilde{p}_L$ and $\eta \geq f(p_L)$. If $p_L > \tilde{p}_L$, then the right-hand side of (A.1) with $j = L$ is greater than the left-hand side for $\eta = 0$ and, therefore, for all η . Hence, a PE exists if either $p_L \leq \tilde{p}_L$ and $\eta \geq f(p_L)$ or $p_L > \tilde{p}_L$.

The function $f(p_L)$ falls from unity to zero as p_L rises from zero to \tilde{p}_L . Figure A.1 illustrates how the emergence of an SE or a PE depends on the parameters p_L and η . For given p_L , the assertion of Proposition 1 follows upon setting $\tilde{\eta} = f(p_L)$.

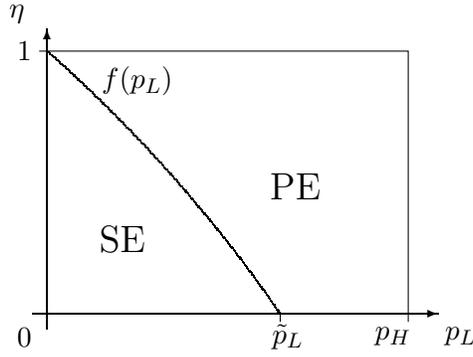


Figure A.1: SE and PE

Proposition 2: Non-existence of a PE follows if there is α such that $U_L^b(P(\alpha), \alpha) > U^r(R_M) > U_H^b(P(\alpha), \alpha)$. $U_j^b(P(0), 0) = u(c - p_L I)$ for $j = L, H$. As shown in the main text, $U_L^b(P(\alpha), \alpha)$ is a decreasing function of α . Obviously, $U_L^b(P(\alpha), \alpha) > U_H^b(P(\alpha), \alpha)$ for $\alpha > 0$. For η large enough such that $U_L^b(P(1), 1) \leq U^r(R_M)$, there exist α' and $\alpha'' (> \alpha')$ in the unit interval such that $U_H^b(P(\alpha'), \alpha') = U^r(R_M) = U_H^b(P(\alpha''), \alpha'')$ and, hence, $U_L^b(P(\alpha), \alpha) > U^r(R_M) > U_H^b(P(\alpha), \alpha)$ for $\alpha' < \alpha < \alpha''$. For η such that $U_L^b(P(1), 1) > U^r(R_M)$, we have, using Jensen's inequality, $U_L^b(P(1), 1) > U^r(R_M) > U_H^b(P(1), 1)$. This proves the non-existence of a PE.

The ownership share $\hat{\alpha}$ which yields maximum expected utility to L-types subject to the H-types' self-selection constraint is determined, independently of η , by $U_H^b(P(\hat{\alpha}), \hat{\alpha}) = U^r(R_H)$, i.e.,

$$(1 - p_H)u(c - (1 - \hat{\alpha})p_L I) + p_H u(c - (1 - \hat{\alpha})p_L I - \hat{\alpha} I) = u(c - p_H I).$$

Since the left-hand side is a continuous function of $\hat{\alpha}$ that falls from $u(c - p_L I)$ to $(1 - p_H)u(c) + p_H u(c - I)$ as $\hat{\alpha}$ rises from zero to unity, $\hat{\alpha}$ exists. The rental contract with rent R_H and the partial ownership contract with ownership share $\hat{\alpha}$ and price $P(\hat{\alpha})$ are an SE if $U^r(R_M) \leq U_L^b(P(\hat{\alpha}), \hat{\alpha})$. From Jensen's inequality,

$$U_L^b(P(\hat{\alpha}), \hat{\alpha}) = (1 - p_L)u(c - p_L I + p_L \hat{\alpha} I) + p_L u(c - p_L I - (1 - p_L)\hat{\alpha} I)$$

is less than $u(c - p_L I)$. From the definition of $\hat{\alpha}$, we have $U_L^b(P(\hat{\alpha}), \hat{\alpha}) > U_H^b(P(\hat{\alpha}), \hat{\alpha}) = u(c - p_H I)$. So $U^r(R_M) > U_L^b(P(\hat{\alpha}), \hat{\alpha})$ for $\eta = 0$ and $U^r(R_M) < U_L^b(P(\hat{\alpha}), \hat{\alpha})$ for $\eta = 1$. Hence, there exists $\hat{\eta}$ such that $U^r(R_M) = U_L^b(P(\hat{\alpha}), \hat{\alpha})$ for $\eta = \hat{\eta}$ and $U^r(R_M) \geq U_L^b(P(\hat{\alpha}), \hat{\alpha})$ for $\eta \leq \hat{\eta}$.

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