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Borrower Mobility, Adverse Selection, and Mortgage Points*

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This paper analyzes a simple mobility-based model of mortgage lending and uses the results to illuminate the issue of mortgage points. The model predicts the points/interest-rate trade-off observed in the market, and it also predicts that mobile borrowers choose low-points/high-rate contracts from the available menu, in conformance with conventional wisdom. These outcomes are shown to be a result of adverse selection, which arises because of the lender's inability to distinguish the mobility characteristics of borrowers. Empirical evidence is also presented showing the presence of a points/interest-rate trade-off in the market. In addition, relying on a proxy variable, the results establish that borrowers choose contracts from this menu according to mobility. *Journal of Economic Literature* Classification Numbers: G21.

1. INTRODUCTION

It is now widely recognized that when a borrower chooses from among the menu of contracts available in the mortgage market, mobility plays an important role in the decision. This effect is perhaps clearest in the choice between fixed- and adjustable-rate mortgages. A highly mobile borrower can exploit the lower initial rate on an ARM loan to enjoy lower payments over the short expected holding period of his mortgage. Mobile borrowers should therefore prefer ARMs over fixed-rate mortgages, a tendency that

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is confirmed empirically by Dhillon *et al.* (1987) and Brueckner and Follain (1988).[1]

Another decision where the role of mobility is generally acknowledged is the choice of mortgage points. Points consist of an up-front fee, expressed as a percentage of the mortgage amount, paid to lender at the time of loan origination. Typically, borrowers are offered a menu of contracts embodying a trade-off between points and the loan interest rate: a high-points loan carries a low interest rate, and vice versa. In making choices from this menu, mobile borrowers place relatively little weight on any interest-rate premium because of their short expected holding period, and are thus drawn to a low-points mortgage. Sedentary borrowers, for whom the loan rate is more important, prefer to pay high points to secure a low rate.

While this description of borrower behavior is widely accepted (see Dunn and Spatt (1988), for example), there have been few attempts to explain why the menu of points/interest-rate choices emerges in the first place. One explanation is provided by Chari and Jagannathan (1989), who develop a model based on income uncertainty.[2] In their framework, the potential mover has a riskier income stream than a sedentary borrower, and a move only occurs when his future income realization is favorable. The optimal mortgage contract provides insurance to the potential mover, which comes in the form of a lower rate (enjoyed in the unfavorable state, where a move does not occur) together with mortgage points, which are forfeited when income is high and the borrower moves. The insurance offered through the mortgage contract is reduced, relative to the full-information case, when the lender cannot distinguish between borrower types. Although this model offers numerous insights, its predictions are exactly the reverse of those sketched above: the mobile borrower chooses a loan with *high* points and a *low* rate, contrary to the conventional wisdom.

The present paper develops a different mobility-based model of mortgage lending that may advance our understanding of mortgage points. The model portrays the borrower as choosing a two-period mortgage with fixed payments that may differ across time. There is no income uncertainty, but there is a chance the borrower moves midway through the term of his mortgage, in which case the second payment is not made. The model has two borrower types differentiated by their probabilities of mov-

[1] See also Sa-Aadu and Sirmans (1990). Brueckner (1992) shows that with a continuum of borrower types differentiated by mobility, the division of borrowers between ARMs and fixed-rate loans is endogenous and dependent on market conditions. For a related analysis, see Rosenthal and Zorn (1993).

[2] Kau and Keenan (1987) develop an alternative model where points emerge as a result of asymmetric tax treatment of lenders and borrowers.

ing, and the analysis explores the nature of the mortgage market equilibrium when these types are indistinguishable to the lender. It is shown that the equilibrium menu of contracts exhibits a trade-off between initial and final payments. The contract with low initial and high final payments is chosen by the high-mobility borrower, while the low-mobility borrower opts for a contract with the reverse features. As in Chari and Jagannathan (1989), the equilibrium involves adverse selection in the sense of Rothschild and Stiglitz (1976). In particular, the lender's inability to distinguish between borrower types distorts the available contract choices, lowering welfare relative to the full-information case.

To see the mortgage-points interpretation of the model, let the initial mortgage payment equal interest plus mortgage points, with the final payment representing interest alone. The trade-off between final and initial payments then implies a trade-off between points and the mortgage interest rate like the one observed in the market. In addition, selection of contracts by borrower types conforms to conventional wisdom: the high-mobility borrower's choice of the low-initial-payment/high-final-payment contract corresponds to a low-points/high-rate choice, and vice versa for the low-mobility borrower. Thus, the analysis shows that a simple mobility-based model is capable of generating equilibria that closely resemble the one envisioned in the conventional view of mortgage points. Moreover, the genesis of mortgage points is shown to be a response to asymmetric information: points are a device by which lenders induce borrowers to self-select across mortgage contracts according to unobserved mobility.

The analysis sketched above is presented in Section 2 of the paper, which also discusses the effect of introducing a prepayment penalty into the model. Many authors argue that mortgage points are a substitute for the prepayment penalty, and the analysis is directed toward evaluating this claim. Section 3 offers empirical evidence relevant to the model using a database compiled by the National Association of Realtors (the data give information on individual loan transactions). The empirical analysis begins by demonstrating that a points/interest-rate trade-off is indeed present in the data. Then, using a proxy for borrower mobility, it is shown that mobile borrowers do in fact choose mortgage contracts with low points, confirming the predictions of the model. Finally, an attempt is made to test for the presence of adverse selection.

2. ANALYSIS

a. *The Model*

All borrowers in the model purchase identical, fixed-size houses. For simplicity, the mortgage used to finance each purchase is assumed to be a

100% loan, with the size of the loan (value of the standard house) normalized to unity. Mortgages have a term of two periods, and they require fixed payments that may differ across time. Payments in the two periods (denoted zero and one) are equal to i_0 and i_1. Note that since the house size is fixed, consumption can be suppressed as an argument of the borrower's utility function, introduced below. Note also that the assumption of a two-period mortgage term is made only for simplicity; use of a longer, more realistic term would have no effect on the analysis. Finally, observe that use of ARM contracts is ruled out, with the analysis exploring the impact of borrower mobility *conditional* on the use of a fixed-payment mortgage. Since ARMs are favored by highly mobile individuals, borrowers in the model can be viewed as representing the less mobile segment of the population.

To represent mobility, it is assumed that the borrower may move at the end of period zero after having made one mortgage payment, an event that occurs exogenously with probability ρ. Different values of ρ distinguish the two borrower types in the model: high-mobility borrowers have $\rho = \rho_h$, and low-mobility borrowers have $\rho = \rho_l$, where $\rho_l < \rho_h$. Both types of borrowers have constant income per period equal to y. In addition, both have the same concave Von Neumann–Morgenstern utility function $V(\cdot)$ as well as the same discount factor δ. Under these assumptions, expected utility for a type-m borrower, $m = h, l$, can be written

$$(1 - \rho_m)[V(y - i_0) + \delta V(y - i_1) + \delta^2\Gamma_m] + \rho_m[V(y - i_0) + \delta\Psi_m]. \quad (1)$$

The first bracketed term in (1) is discounted utility when no move occurs, an event that has probability $(1 - \rho_m)$ for $m = h, l$. Γ_m in this expression equals type-m expected utility as of period two given that a move did not occur in period one. Similarly, the second bracketed expression is discounted utility given that a move did occur (Ψ_m equals expected utility as of period one in this case). The quantities Γ_m and Ψ_m, which reflect the outcome of future decisions, are assumed to be independent of i_0 and i_1.[3]

Observe that (1) does not include a downpayment on the house purchase or a return of housing equity upon sale, a consequence of the assumption of 100% financing. In addition, it should be noted that the present formulation rules out *financially motivated* mortgage prepayment,

[3] Note that saving and non-mortgage borrowing is suppressed in the model. If additional borrowing to help defray mortgage costs were allowed, then high mortgage payments would reduce future disposable income because of the need to repay these supplementary loans. In this case, Γ_m and Ψ_m would depend on i_0 and i_1.

i.e., refinancing. Incorporating such prepayment would complicate the model, obscuring the main points of interest.[4]

Indifference curves in (i_0, i_1) space differ between high-mobility and low-mobility borrowers, and this difference is central to the analysis. Differentiating (1), the marginal rates of substitution between i_1 and i_0 for the type-h and type-l borrowers are equal to

$$\mathrm{MRS}_h \equiv \frac{V'(y - i_0)}{\delta(1 - \rho_h)V'(y - i_1)} > \mathrm{MRS}_l \equiv \frac{V'(y - i_0)}{\delta(1 - \rho_l)V'(y - i_1)}, \qquad (2)$$

where the inequality follows because $\rho_h > \rho_l$. The indifference curves of the type-h borrower are therefore steeper than those of the type-l borrower in (i_0, i_1) space. Differentiating (2), it is easily seen that the indifference curves are concave (also, utility increases moving toward the origin).

Lenders rely on short-term borrowing to generate loanable mortgage funds. The cost per dollar of funds in period zero is denoted r_0, and the expected cost in period one is denoted r_1. It is important to note that r_0 includes both the interest cost of short-term funds and the administrative costs of mortgage origination, which are incurred in period zero. Therefore, $r_0 > r_1$ is likely to hold even in the case where the lender's borrowing costs are expected to rise over time.

The lender is assumed to be risk neutral and to discount future profit by the factor θ. Expected profit per dollar of loan to a type-m borrower is then

$$(1 - \rho_m)[i_0 - r_0 + \theta(i_1 - r_1)] + \rho_m(i_0 - r_0), \qquad m = h, l. \qquad (3)$$

The term in brackets is discounted profit when the borrower does not move, and $i_0 - r_0$ is discounted profit when a move occurs (in the latter case, no mortgage income is earned in period one). Setting (3) equal to zero and rearranging yields the zero-profit locus for type-m lending:

[4] Empirical evidence on refinancing is provided by Green and Shoven (1986), Quigley (1987), and Quigley and Van Order (1990). Analysis of financially motivated prepayment also underlies option-based models of mortgage pricing, which are developed by Hall (1985), Kau *et al.* (1992), and Follain *et al.* (1992) (see the survey article by Hendershott and Van Order (1987) for further references). The key insight of these models is that the mortgage interest rate incorporates the cost of the prepayment option. While Follain *et al.* (1992) demonstrate that mortgage points can also be viewed as covering this cost, points appear to be redundant in their framework (i.e., points are not shown to be a necessary feature of mortgage contracts).

$$i_1 = r_1 + \frac{r_0 - i_0}{\theta(1 - \rho_m)}, \qquad m = h, l. \tag{4}$$

The loci described in (4), which give combinations of i_0 and i_1 where type-m lending yields zero expected profit, are downward-sloping straight lines. The type-h locus is steeper than the type-l locus given $\rho_h > \rho_l$, and the loci intersect at the point $(i_0, i_1) = (r_0, r_1)$, as shown in Fig. 1.

Referring to Fig. 1, it is evident that the zero-profit i_1 value for the h types can be higher or lower than the value for the l types, depending on whether i_0 is below or above r_0. Intuitively, if $i_0 < r_0$, then zero profit requires that the lender earn a positive profit on period-one lending (i.e., $i_1 > r_1$). The excess of i_1 above r_1, however, must be greater for the h types since the profit has a lower probability of being realized. The type-h locus must therefore lie above the type-l locus to the left of the intersection. A parallel argument shows the loci must have the reverse relationship to the right of the intersection.

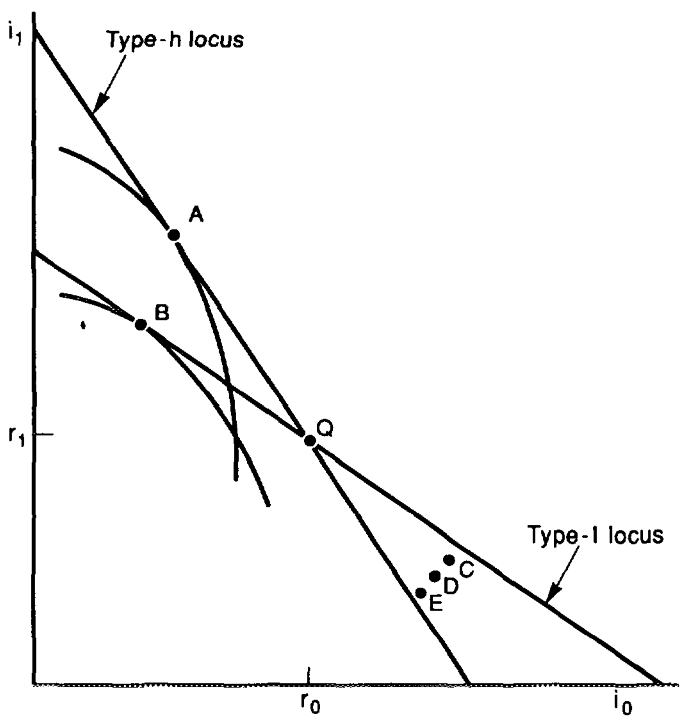

FIG. 1. Zero-profit loci and indifference curves.

b. *Equilibrium*

The first step in the analysis of equilibrium is to establish the relationship between the indifference curves and the zero-profit loci. Suppose that a type-h indifference curve is tangent to the type-h zero-profit locus above the intersection point of the two loci (denoted Q), as shown in Fig. 1. Then the tangency point between a type-l indifference curve and the type-l locus must also lie above Q, as shown. Generally, *the tangency points between indifference curves and the respective zero-profit loci for the two types lie on the same side of Q*. To establish this fact, observe that the type-m tangency point will be above (below) Q when the indifference curve is steeper (less steep) than the locus at Q, or as

$$\frac{V'(y - r_0)}{\delta(1 - \rho_m)V'(y - r_1)} > (<) \frac{1}{\theta(1 - \rho_m)}, \qquad m = h, l \tag{5}$$

(the slope expressions come from (2) and (4)). However, since the $(1 - \rho_m)$ term cancels on both sides of this inequality, it follows that if the inequality holds for one borrower type, it holds for both, establishing the above claim.

From (5), the location of both tangency points relative to Q depends on parameter values. If $r_0 = r_1$ and $\delta = \theta$, then both sides of (5) are equal, and each indifference curve is tangent to its respective zero-profit locus at Q. However, a decline in δ relative to θ or a decline in r_1 relative to r_0 makes each indifference curve steeper than its respective locus at Q. Tangencies above Q thus result from a relatively low valuation of the future by the borrower or a low future cost of funds, with the reverse cases yielding tangencies below Q.

Also, it can be shown that a tangency point on the lower zero-profit locus must lie to the *southwest* of a tangency on the upper locus. Thus, point B in Fig. 1 must lie to the southwest of point A, as shown, and the same relationship must hold when the tangencies are located below Q.[5]

[5] This fact can be established as follows. Since

$$\frac{V'(y - i_0^A)}{\delta(1 - \rho_h)V'(y - i_1^A)} = \frac{1}{\delta(1 - \rho_h)}$$

holds at point A in Fig. 1, it follows that

$$\frac{V'(y - i_0^A)}{\delta(1 - \rho_l)V'(y - i_1^N)} > \frac{1}{\delta(1 - \rho_l)}$$

holds at point N (not shown), which lies on the type-l locus directly below A (its coordinates

With this background, the analysis of equilibrium can proceed, using the approach of Rothschild and Stiglitz (1976). While analysis of markets with asymmetric information has advanced well beyond the early Rothschild–Stiglitz model, this "old-fashioned" approach yields fresh insights in the present context, as will be seen below. Consider first the full-information case, where the lender can identify borrowers by type. In this case, the lender can earmark a particular mortgage contract for a given type of borrower, preventing the other type from choosing it. A full-information equilibrium consists of a set of mortgage contracts and an assignment of borrowers to contracts such that[6]

(i) lenders earn zero profit
(ii) no contract outside the set attracts borrowers while earning nonnegative profit.

Under full information, the equilibrium contracts correspond to the tangency points on the zero-profit loci for the two types of borrowers. Thus, contracts A and B, assigned to type-h and type-l borrowers, respectively, constitute the full-information equilibrium in the situation shown in Fig. 1. In the alternate case, equilibrium contracts lie at tangencies below Q.[7]

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are (i_0^A, i_1^N)). Therefore, the type-l indifference curve is steeper than the type-l locus at N, implying that the tangency is located uphill from N. Similarly,

$$\frac{V'(y - i_0^P)}{\delta(1 - \rho_l)V'(y - i_1^A)} < \frac{1}{\delta(1 - \rho_l)}$$

holds at point P (not shown), which lies on the type-l locus directly to the left of A (its coordinates are (i_0^P, i_1^A)). The type-l indifference curve is thus flatter than the locus at point P, implying that the tangency lies downhill from P (note that point P may have a negative i_0 coordinate, a possibility that has no effect on the argument). While this argument ignores potential corner solutions, the result in the text applies as long as at least one of the indifference curves is tangent to its respective locus. Finally, analogous reasoning applies to the case where the tangencies are below the intersection point.

[6] Other adverse-selection models rely on definitions of equilibrium different from the one used by Rothschild and Stiglitz. See Miyazaki (1977) and Wilson (1977).

[7] To establish this claim, the first step is to observe that individual contracts must break even, ruling out cross subsidies. To see this, suppose that in equilibrium, each lender were to offer contracts C and D in Fig. 1, assigned to type-l and type-h borrowers, respectively. C lies below the type-l locus and is thus unprofitable, but the loss is made up by the profit earned on contract D, which lies above the type-h locus. In this situation, if the alternative contract E, earmarked for type-h borrowers, were offered by some lender, it would be profitable and would attract h types away from contract D, in violation of requirement (ii) above. Note that the same conclusion would apply in the "pooling" case where contracts C and D are identical. The upshot is that contracts must break even on an individual basis, lying on the two zero-profit loci. Moreover, unless each contract coincides with the tangency point on its respective locus, there will exist preferred contracts that are profitable, in violation of (ii).

In the full-information equilibrium shown in Fig. 1, the type-h borrower prefers the contract assigned to the type-l borrower (contract B) to his own assignment (contract A). Earmarking prevents the type-h individual from selecting this preferred option. When the lender cannot distinguish between borrower types, however, earmarking is not possible and borrower separation across contracts must be voluntary. Equilibria must then satisfy incentive-compatibility constraints, which state that each borrower type weakly prefers the contract designed for his type to the one designed for the other type (note that "assigning" contracts to types is no longer feasible since the types are not observable).

To satisfy the relevant incentive-compatibility constraint, the type-l contract must be moved to a position on the zero-profit locus where it is no longer strictly preferred by the type-h borrower. Such a position is shown in Fig. 2 as contract F. Contracts downhill from F also satisfy the incentive-compatibility constraint, but they leave profit opportunities for lenders. Equilibrium contracts are therefore F and A.

In the alternate case where the full-information contracts lie below Q

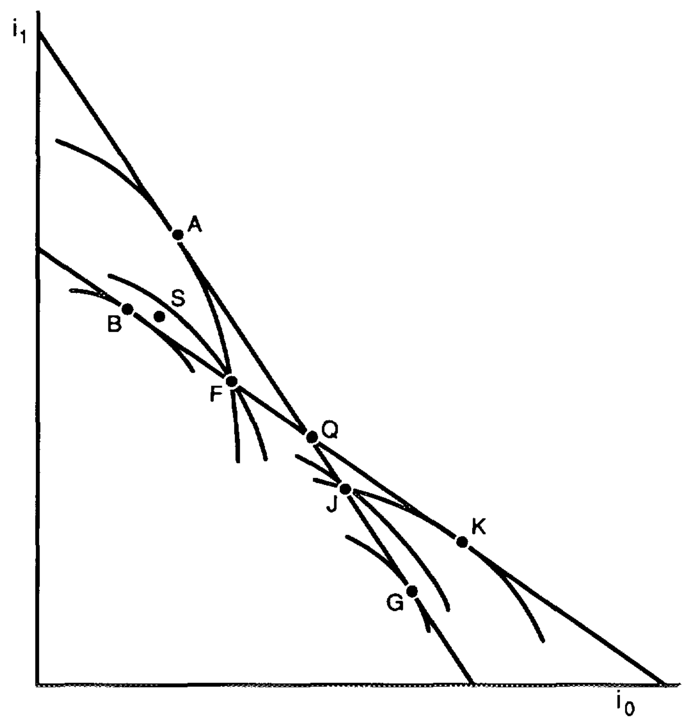

FIG. 2. Equilibria.

(see Fig. 2), the type-l borrower prefers the type-h contract (G) to the one assigned to him (K). To satisfy the relevant incentive-compatibility constraint, the type-h contract must be relocated to the position shown as J. Equilibrium contracts in this case are thus J and K.

Several features of these equilibria are noteworthy. First, observe that regardless of which case applies, the equilibrium set of contracts exhibits a trade-off between initial and final payments. Comparison of the contracts (A vs F, and J vs. K) shows that one has a high i_0 and a low i_1, while the other has the reverse features. Moreover, in both cases, the high-mobility borrower chooses the low-i_0/high-i_1 contract, while the low-mobility borrower chooses the contract with the reverse features.

The second noteworthy aspect of the equilibria is that adverse selection lowers the welfare of one borrower type relative to the full-information case. When the tangencies are above Q, the type-l borrower is hurt by the lender's inability to distinguish the types (he gets contract F instead of B). Conversely, when the tangencies are below Q, the type-h borrower is hurt. These two possibilities provide an apparent contrast to the standard outcome, where a particular class of agent (the "low-risk" individual) is harmed by adverse selection (see Rothschild and Stiglitz (1976)). However, this contrast disappears upon closer inspection when it is realized that a borrower's "riskiness" is endogenous in the present model and depends on the magnitude of i_0. In particular, when $i_0 > r_0$ holds, so that $i_1 < r_1$ and period-one profit is negative, the "high-risk" borrower is the type-l individual, whose low ρ forces the lender to absorb this loss with high probability. Similarly, the type-h individual is the high-risk borrower in the case where $i_0 < r_0$ (he generates the required period-one profit with low probability). Thus, in each case, the borrower harmed by adverse selection is of the low-risk type, as in Rothschild and Stiglitz.

The preceding discussion must be qualified to take into account the possible nonexistence of equilibrium. The nonexistence problem may arise when the borrower population is unbalanced, with either the h types or the l types representing a large fraction of the total. To see this, consider the case where the tangencies are above Q, and suppose that the population is made up almost entirely of l types. Then, even though it lies far below the type-h locus, a contract such as S in Fig. 2 could earn a profit if both borrower types were to choose it. But given its position, S is indeed preferred to the respective choices F and A, which implies that F and A cannot represent equilibrium contracts. However, since choice of S by both types is itself not an equilibrium outcome (cross subsidies are present), it follows that equilibrium does not exist. It is easy to see that the same conclusion holds when the tangencies are below Q and the population share of the h types is very high. To rule out these nonexistence cases, the population must be balanced, with neither type's share being high. This assures that a contract like S in Fig. 2 generates negative profit when both borrowers choose it (a similar conclusion holds below Q).[8]

c. *Mortgage Points*

As explained in the Introduction, the model has a mortgage-points interpretation. To see this, let the period-one payment represent the mortgage interest rate, and let the period-zero payment equal the interest rate plus mortgage points. In other words, $i_1 = t$ and $i_0 = t + p$, where t is the interest rate and p is points (recall that i_0 and i_1 are payments per dollar of loan, and that the mortgage size is normalized to one). Then, for points to emerge in equilibrium, it must be the case that the equilibrium contracts satisfy $i_0 > i_1$, lying below the 45-degree line in Fig. 2 (otherwise, $p < 0$).

Supposing for the moment that the equilibrium satisfies this requirement, it has a number of realistic features. First, the trade-off between i_0 and i_1 noted above generates a trade-off between mortgage points and the interest rate like the one observed in the market. Referring to contracts J and K, the inequalities $i_1^{\mathrm{J}} > i_1^{\mathrm{K}}$ and $i_0^{\mathrm{J}} < i_0^{\mathrm{K}}$ imply $t^{\mathrm{J}} > t^{\mathrm{K}}$ and $t^{\mathrm{J}} + p^{\mathrm{J}} < t^{\mathrm{K}} + p^{\mathrm{K}}$. Subtracting the latter inequalities yields $p^{\mathrm{J}} < p^{\mathrm{K}}$, so that contract J has low points and a high interest rate relative to contract K. Moreover, borrowers choose from the points/interest-rate menu according to conventional wisdom: the high-mobility borrower chooses J, the low-points/high-rate contract, while the low-mobility borrower chooses the K, the high-points/low-rate contract. Similar observations apply when the equilibrium lies above Q.

A problem with this points interpretation is that nothing in the model guarantees that the equilibrium contracts lie below the 45-degree line. Indeed, instead of voluntarily selecting mortgages with front-loaded payments, as required under the points interpretation, impatient borrowers are likely to prefer contracts where payments *rise* over time (satisfying $i_0 < i_1$). This outcome, however, violates a constraint imposed on real-world contracts that so far has been omitted from the model. The constraint rules out mortgages with *ascending* payment streams, which may lead to negative amortization and thus expose the lender to default risk.

These observations suggest that a more realistic model might impose

[8] A related argument shows that if the population is unbalanced, then the equilibrium, when it exists, may be inefficient in a second-best sense. In other words, even in cases where an equilibrium exists, a planner who is unable to identify the borrowers by type may be able to enforce a welfare-improving zero-profit contract. Focusing on the above-Q case, this occurs when the pooling zero-profit locus, which is the weighted average of the individual loci, is tangent to the indifference curve passing through F. In this situation, the contract at the tangency point is weakly preferred by both borrower types while generating zero profit. However, because the contract does not attract the l types away from F, which offers the same utility, F and A constitute an equilibrium, which is then second-best inefficient.

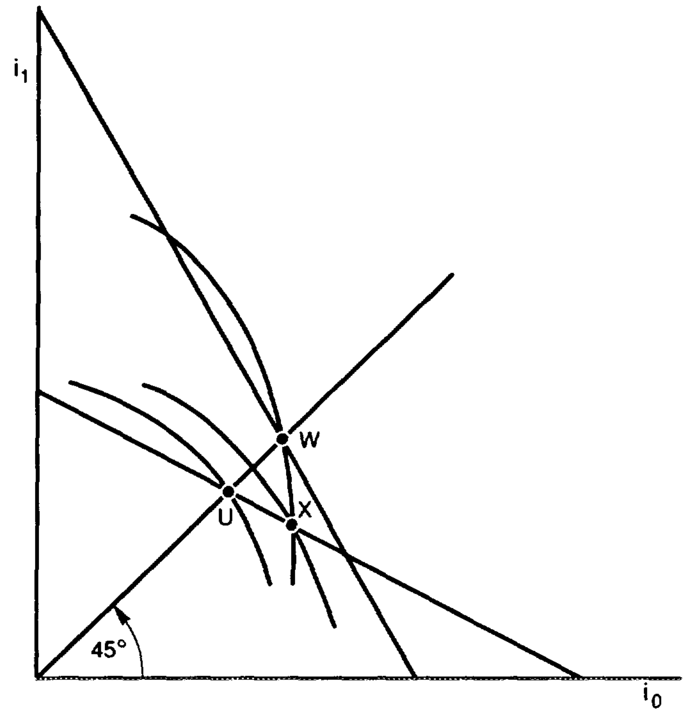

FIG. 3. The constrained case.

the constraint $i_0 \geq i_1$ while assuming that borrowers prefer an ascending payment stream. Full-information contracts would then consist of corner solutions with $i_0 = i_1$, located where the 45-degree line crosses the respective zero-profit loci. Borrowers are then liquidity-constrained, desiring greater disposable income in period zero but unable to secure it. The nature of equilibria under such a modification depends on the location of Q relative to the 45-degree line, which in turn depends on the relative magnitudes of its coordinates, r_0 and r_1. Figure 3 shows the case where Q lies below the line, which requires $r_0 > r_1$. This case is most plausible given that r_0 includes the administrative costs of mortgage origination, while r_1 represents pure borrowing costs (see above).

Contracts W and U in Fig. 3 constitute the full-information contracts, which are corner solutions involving zero points ($i_0 = i_1$). Equilibrium contracts under asymmetric information are W and X, chosen by the type-h and type-l borrowers, respectively. The key feature of this equilibrium is that while both borrower types prefer zero-points contracts, asymmetric information prevents the type-l borrower from satisfying this preference. Separation of the borrower types can only be achieved by offering the l type an inferior choice (contract X) that involves payment of positive points. It should be noted that this outcome depends critically on the assumption that Q lies below the 45-degree line. If Q instead lies above the line, borrowers' choices do not follow conventional wisdom, with the positive-points contract chosen by the type-h instead of the type-l borrower.[9] Thus, the presence of administrative costs, which makes $r_0 > r_1$ a plausible assumption, is critical in generating an equilibrium with the expected features.

This discussion shows that when the constraint $i_0 \geq i_1$ is imposed and Q is realistically below the 45-degree line, all equilibria conform to the points interpretation. In the case where the constraint is binding, and in the alternative case where it is not, the equilibrium contains a menu of contracts that exhibits a trade-off between i_0 and i_1, implying a trade-off between points and interest rate, and borrowers select from the menu according to conventional wisdom. Since all equilibria have this property, the model thus *explains* the emergence of mortgage points. The analysis suggests that points serve as a device by which lenders induce borrowers to self-select across mortgage contracts according to unobserved mobility. The resulting need to satisfy an incentive-compatibility constraint, which forces both equilibrium contracts to lie on a single indifference curve for one borrower type, generates a trade-off between points and the mortgage interest rate.[10]

While the model assumes asymmetric information, it is interesting to note that identical results would emerge if earmarking of mortgage contracts were legally prohibited. To see this, suppose that information were perfect, with lenders able to identify type-h and type-l borrowers, but that legal restrictions were to prevent lenders from assigning borrowers to contracts on the basis of personal characteristics. Then, despite the presence of full information, equilibrium contracts would need to satisfy an incentive-compatibility constraint, with the attendant distortions of choice. The points/interest-rate trade-off, then, can arise either from asymmetric information or from legal prohibitions on earmarking.

[9] In the alternate case where Q lies above the 45-degree line, a diagram analogous to Fig. 3 shows that in equilibrium, the low-mobility borrower selects his full-information contract (the corner solution on the 45-degree line), while the high-mobility borrower selects the contract located at the intersection of his zero-profit locus and the low-mobility borrower's indifference curve. The resulting equilibrium has the low-mobility borrower choosing a zero-points mortgage and the high-mobility borrower choosing a positive-points contract.

[10] Yang (1992) shows that, as in the present model, zero-profit points/interest-rate combinations differ among borrowers with different mortgage holding periods. However, in contrast to the present discussion, he claims that a separating equilibrium, where borrower types choose different contracts, does not exist.

d. *The Effect of a Prepayment Penalty*

Prepayment penalties, which force the borrower to pay a fee to the lender if the mortgage is paid off prematurely, are infrequently used in the United States. However, many commentators view points and prepayment penalties as perfect substitutes, noting that points (like the prepayment penalty) represent a sizable sum that is forfeited when the mortgage is prepaid (see Chari and Jagannathan (1989) and Kau and Keenan (1987), for example). Given this view, it is interesting to investigate the effect of a prepayment penalty in the present model.[11] The ensuing analysis shows that, in the presence of adverse selection, the prepayment penalty is *not* a perfect substitute for mortgage points. Introduction of such a penalty can either raise or lower welfare, depending on the nature of the equilibrium.

Let s denote the prepayment penalty per dollar of loan, which is paid in the event that the loan is terminated after period zero. With this modification, the last term in the expected utility expression (1) is replaced by $\rho_m[V(y - i_0 - s) + \delta\Psi_m]$, and the last term in the profit expression (3) is replaced by $\rho_m(i_0 - r_0 + s)$. Introduction of the penalty corresponds to an exogenous increase in s, starting from a situation where $s = 0$. As will be seen, the effect of this perturbation depends on whether the equilibrium contracts lie above or below Q. The analysis focuses on an equilibrium where the constraint $i_0 \geq i_1$ is not binding, and the below-Q case is treated first (for concreteness, the equilibrium contracts are labeled J and K, as in Fig. 2).

The low-mobility borrower, who chooses contract K, satisfies the tangency condition when $s = 0$, and he will continue to do so after a marginal increase in s. Therefore, the impact on his choices can be found by totally differentiating the following equations with respect to s, evaluating at $s = 0$:

$$\frac{(1 - \rho_l)V'(y - i_0^K) + \rho_l V'(y - i_0^K - s)}{\delta(1 - \rho_l)V'(y - i_1^K)} = \frac{1}{\theta(1 - \rho_l)} \tag{6}$$

$$i_1^K = r_1 + \frac{r_0 - i_0^K - \rho_l s}{\theta(1 - \rho_l)}. \tag{7}$$

Equation (6) is the tangency condition, and its left-hand side equals the new MRS (reflecting the modification of (1)) evaluated at K. Equation (7) is the modified zero-profit condition. Differentiating (6) and (7) yields, after some manipulation,

$$\frac{\partial i_1^K}{\partial s} = 0 \quad \text{and} \quad \frac{\partial i_0^K}{\partial s} = -\rho_l. \tag{8}$$

[11] Dunn and Spatt (1985) offer a related analysis of prepayment penalties.

From (8), introduction of the prepayment penalty has no effect on i_1 for the type-l borrower while lowering i_0. Under the points interpretation, introduction of the penalty thus leaves the interest rate (i_1) unchanged while lowering points by an amount $\rho_l ds$, equal to the expected penalty. Moreover, as shown in the Appendix, the penalty has no effect on the welfare of the type-l borrower. Thus, when the borrower is initially at a tangency, the prepayment penalty is indeed a perfect substitute for mortgage points.

In the full-information case, contract G would be selected by the type-h borrower, and the above conclusions (which apply to any tangency solution) would hold. Both borrowers would then be unaffected by introduction of the prepayment penalty. With adverse selection, however, the type-h borrower chooses contract J, and the impact of an increase in s is evaluated by differentiating another set of equations. The first is a zero-profit condition analogous to (7). The second is a condition requiring the expected utility of the type-h contract, evaluated from the type-l borrower's point of view, to remain constant as s increases. This condition forces the type-h contract to remain on a fixed type-l indifference curve as s rises, as required in an adverse-selection equilibrium (the indifference curve is fixed because type-l utility is unaffected as s rises). As shown in the Appendix, differentiation of these conditions yields

$$\frac{\partial i_1^{\mathrm{J}}}{\partial s} > 0 \tag{9}$$

as well as

$$\frac{\partial i_0^{\mathrm{J}}}{\partial s} > (<)\ 0 \qquad \text{and} \qquad \frac{\partial i_0^{\mathrm{J}} - i_1^{\mathrm{J}}}{\partial s} < 0. \tag{10}$$

Introduction of the prepayment penalty thus has an ambiguous effect on i_0 for the type-h borrower, while raising $t = i_1^{\mathrm{J}}$ and lowering $p = i_0^{\mathrm{J}} - i_1^{\mathrm{J}}$. Since the decline in points is accompanied by an increase in the interest rate, points and the prepayment penalty are *not* perfect substitutes from the perspective of the type-h borrower. This nonequivalence generates a welfare impact, which the Appendix shows to be negative: expected utility *falls* for the type-h borrower as the penalty is introduced.

To gain some insight into this result, compare the case where the tangencies are above Q and the type-l borrower is the one hurt by adverse selection. The Appendix shows that in this case, introduction of the prepayment penalty has no effect on the type-h borrower while *raising* the welfare of the type-l borrower. The penalty thus affects the borrower who is harmed by adverse selection, but the direction of the impact hinges on the borrower's identity. When the affected borrower is of type h, a loss occurs; when the borrower is of type l, a welfare gain emerges. These results arise because the prepayment penalty imposes a disproportionate burden on the high-mobility borrower, who is more likely to pay it. If type-h welfare is already compromised by adverse selection, addition of this extra burden lowers it further. While the burden's (first-order) impact vanishes when the type-h borrower is at a tangency point, the change nevertheless improves the lot of the type-l borrower, who finds that the burden of adverse selection lessens.

3. EMPIRICAL EVIDENCE

The purpose of the empirical work is to test three hypotheses that emerge from the preceding analysis. The first is that the menu of available mortgage contracts exhibits a points/interest-rate trade-off. Since this hypothesis is obviously true on the basis of casual empiricism, the only task is to verify that the trade-off exists in the present data. The second hypothesis is that mobile borrowers choose low-points/high-rate contracts. While verification of this hypothesis supports the model, it can also be viewed as a corroboration of conventional wisdom independent of the model. The third hypothesis is that the mortgage market equilibrium involves adverse selection. This hypothesis is, of course, not part of conventional wisdom, and empirical evidence in favor of it would lend support to the present framework.

a. *Data*

Empirical evidence is developed using the Home Financing Transaction Database compiled by the National Association of Realtors (NAR). This database comes from a quarterly nationwide survey of a select panel of real estate brokers, and it provides detailed information about individual mortgage transactions, including features of the mortgage contract, characteristics of the borrower, and characteristics of the property. The empirical analysis focuses on transactions for the four years 1988–1991. A number of additional restrictions are applied to generate the sample. First, only 30-year fixed-rate mortgages are included, consistent with the model's focus on fixed-payment contracts. Attention is also restricted to conventional contracts (FHA and VA mortgages are thus excluded). Contracts involving a second or third mortgage, seller-paid points, interest-rate buydowns, a mortgage assumption, or seller financing are also excluded. Finally, observations are excluded if there are missing values for any of the borrower-characteristics variables used to compute the mobility proxy (discussed below), as are observations with missing mortgage

TABLE I
THE SAMPLE DISTRIBUTION OF MORTGAGE POINTS[a]

POINTS	Observations
5	1
25	4
38	1
50	1
75	2
88	1
100	58
125	4
138	2
150	30
163	1
175	8
185	1
187	1
200	131
220	1
225	9
238	1
250	29
265	1
275	4
288	3
300	106
325	2
338	1
350	5
375	2
400	5
450	2
750	1
Total	418

[a] POINTS is measured in basis points.

points. The resulting sample has 418 observations, fairly evenly distributed across the sample years. The mean interest rate in the sample is 9.96%, and the distribution of mortgage points is shown in Table I. Because of coding ambiguities, the sample contains no zero-points mortgages.[12]

[12] The problem is that there are no mortgages in the NAR data where POINTS is recorded as zero. Evidently, zero-points contracts instead have a missing value for this variable. However, since it is likely that some observations where POINTS is missing actually had positive values that were not recorded, it is illegitimate to treat all missing values as zeros. Given this ambiguity, all such observations are deleted.

b. *Rate Regressions*

The first step in the empirical analysis is to verify that the data exhibit a trade-off between the mortgage interest rate (denoted RATE) and points (POINTS). This is done by regressing RATE on POINTS, controlling for temporal and regional effects. Temporal effects are represented by dummy variables indicating the month and year in which the mortgage transaction occured. Regional dummy variables (representing the Northeast, Midwest, and South) capture differences in mortgage rates across regions of the country. The estimating equations embody several different specifications of the connection between RATE and POINTS. In the first, POINTS enters linearly in the equation, implying that the marginal RATE discount from an increase in POINTS is the same over the entire range of the variables. As seen in the first column of Table II, the POINTS coefficient under this specification is statistically significant and equal to −0.0758, indicating that a 100-basis-point increase in points yields a 7.6-basis-point reduction in RATE (for example, RATE might fall from 9.576% to 9.500%).[13] This estimate does not conform to the "rule-of-thumb" cited in the literature, which asserts that RATE should fall by 12 to 25 basis points for each 100-basis-point increase in POINTS (see, for example, Yang (1992)). The bottom end of the rule-of-thumb range is, however, contained within the 95% confidence interval, which extends slightly above 12. These conclusions are largely unaffected by estimating a modified equation that allows the POINTS coefficient to change over time.[14]

Another approach is to classify mortgages into high-points and low-points ranges, indicated by a dummy variable. Table II shows the effect of two different classifications, which define a high-points mortgage to be a contract with POINTS greater than or equal to 200 (alternatively, 250) basis points. Under both classifications, the high-points dummy variable coefficient is statistically significant, and its magnitude indicates that a high-points contract carries a rate discount of about 13 basis points. Since the mean POINTS difference between high- and low-points contracts is near 137 basis points under both classifications, this implies a rate of

[13] The coefficients of the region and time dummies are not reported. A larger sample, which includes observations with missing values for some borrower-characteristics variables, is used for the rate regressions. This sample has 790 observations.

[14] By including interaction terms, the modified equation allows the coefficient on POINTS to vary by month. When the implied partial derivative of RATE with respect to POINTS is evaluated at the sample-mean values of the month dummies, the impact is equal to −0.0822, a value close to that in Table II. Alternatively, on the assumption that the results in Table II are due to the absence of zero-points mortgages, observations with missing POINTS were added to the sample and assigned a POINTS value of zero (see footnote 18). This modification had no effect on the results, with the regression yielding a POINTS coefficient of −0.0756.

TABLE II
POINTS COEFFICIENTS IN RATE REGRESSIONS[a]

POINTS enters equation as:	Coefficient
Linear variable	−0.0758 (3.17)
Dummy equal to one when POINTS ≥ 200	−12.77 (2.92)
Dummy equal to one when POINTS ≥ 250	−13.18 (3.24)

[a] t statistics are in parentheses; observations = 790.

discount of around 9.5 basis points for a 100-basis-point increase in POINTS, which is nearer the rule-of-thumb range than the previous coefficient.

c. *Mobility Proxy*

To test the hypothesis that mobile borrowers choose low-points mortgages, a proxy for mobility is needed. Brueckner and Follain (1988), who used the same NAR database to investigate the FRM–ARM choice, measured mobility through a dummy variable NEWCITY indicating whether the borrower is new to the metropolitan area (intermetropolitan movers were expected to be more mobile than intrametropolitan movers). Since the effect of the NEWCITY variable on mortgage points is not statistically significant, a different mobility proxy is constructed. This is done using panel data from the American Housing Survey (AHS). Since borrower mobility is *observed* in the AHS sample, it is possible to estimate a probit equation relating mobility to household characteristics. The coefficients from this equation are then applied to the NAR data, where actual mobility is *unobserved*, to generate a move probability for each household.

The AHS sample consists of a set of 2106 houses that were purchased between 1984 and 1985 using a fixed-rate mortgage and were observed again in 1989. Mobility patterns for the initial occupants of these houses are explained using a probit equation. The dependent variable is set equal to one if the initial occupant had moved by 1989 and is set equal to zero otherwise. After some experimentation, the following variables, which are common to both the NAR and the American Housing Survey databases, were selected to explain observed mobility: regional dummies for the Northeast, Midwest, and South (NEAST, MIDWEST, and SOUTH); a dummy indicating whether the home purchased in 1985 was a detached single-family dwelling (SINGLFAM); a dummy indicating whether the household was a first-time homebuyer (FRSTHOME); a dummy indicating whether the household's residence prior to 1985 was in the same metropolitan area (SAMECITY, equal to 1 − NEWCITY above); a dummy indicating whether the household contained a married couple (MARRIED); the age of the household head in 1985 (AGE); the number of bedrooms in the home (BEDRMS); the home's purchase price (PRICE); the log of household income (LINC); the number of children in the household (KIDS); and a dummy variable indicating a central city location in 1985 (CENTCITY).

The probit results are presented in Table III. The results show lower mobility in the Northeast and Midwest than in the West (the default region) and relatively low mobility among older buyers and among buyers of expensive, single-family detached houses. Mobility is also low among intrametropolitan movers, confirming Brueckner and Follain's expectation for this variable (the coefficients of all these variables are statistically significant). While mobility also appears to be lower among married households with children, among first-time buyers and central-city households, and among high-income households, none of these effects is statistically significant (house size as measured by BEDRMS also has no effect).

To generate a mobility proxy for use in explaining the POINTS choice, the estimated coefficients in Table III are used to compute the probability of moving for each household in the NAR sample, denoted PROBMOVE (from above, the relevant time horizon is four years). The sample mean value of PROBMOVE is 0.290, and the minimum and maximum values are 0.051 and 0.563, respectively.

d. *The Effect of Mobility on POINTS*

The most direct way to test the hypothesis that high-mobility borrowers choose low-points mortgages is to regress POINTS on PROBMOVE. Ordinary least-squares (OLS) results for this regression are reported in the first column of Table IV. The estimated coefficient of PROBMOVE is negative, as expected, and statistically significant. Its magnitude of −168 shows that when a borrower's probability of moving rises by 0.10, POINTS decreases by 17 basis points. Note that the significant impact of PROBMOVE emerges despite the fact that the R^2 for the equation is quite small (under 2%). The third column of Table IV shows the effect of adding LINC and FRSTHOME to the regression, variables that may reflect the household's ability to pay extra costs at the time of mortgage origination. While these variables affect POINTS in a plausible manner (positively for LINC and negatively for FRSTHOME), both coefficients are insignificant. Moreover, use of these additional variables has little effect on the

TABLE III
PROBIT ESTIMATES OF THE MOBILITY EQUATION[a]

Variable	Coefficient
CONSTANT	0.8219 (2.45)
NEAST	−0.3001 (3.25)
MIDWEST	−0.2486 (2.91)
SOUTH	−0.0701 (0.89)
SINGLFAM	−0.1650 (2.31)
FRSTHOME	−0.0709 (1.08)
SAMECITY	−0.1645 (2.77)
MARRIED	−0.0183 (0.27)
AGE	−0.0059 (2.05)
BEDRMS	−0.0530 (1.31)
PRICE	−0.0015 (2.23)
LINC	−0.0227 (0.78)
KIDS	−0.0092 (0.34)
CENTCITY	−0.0506 (0.79)

[a] Dependent variable is one if a move occured and zero otherwise; asymptotic t statistics are in parenthesis; observations = 2106, χ^2 = 54.30.

magnitude and significance level of the PROBMOVE coefficient. Observe, however, that despite some improvement, the R^2 for the regression remains low, suggesting that other, unobserved variables may play a role in the choice of POINTS.

TABLE IV
REGRESSIONS RELATING POINTS TO PROBMOVE[a]

	Coefficients			
Variable	OLS	GLS	OLS	GLS
CONSTANT	265.31 (14.80)	265.84 (13.11)	234.31 (1.66)	201.60 (1.38)
PROBMOVE	−167.73 (2.78)	−165.87 (2.57)	−151.67 (2.10)	−142.29 (1.90)
LINC	—	—	2.67 (0.23)	5.53 (0.45)
FRSTHOME	—	—	−15.51 (1.41)	−14.18 (1.25)
R^2	0.018	0.018	0.024	0.024

[a] t statistics (or asymptotic t statistics) are in parentheses; observations = 418.

Given that PROBMOVE is the estimated (instead of true) probability of moving, the error term in the above regression does not satisfy the assumptions required for application of OLS. In particular, the error term includes the difference between the estimated and the true move probabilities, a quantity that in turn depends on the estimated probit coefficients from Table III. Because these coefficients enter the error term for each observation, all the errors are correlated, implying that generalized least-squares (GLS) is the appropriate estimation technique. Application of this technique, which is explained in an appendix available on request, leads to the results in columns 2 and 4 of Table IV. Although the t statistics for PROBMOVE fall somewhat, the estimates are generally similar to the OLS results.

e. *Is There Evidence of Adverse Selection?*

By showing that mobile borrowers choose low-points contracts, the preceding results confirm one of the model's central predictions. However, because this prediction also coincides with conventional wisdom, the results cannot be viewed as a stringent test of the model. A stringent test would provide evidence that the underlying equilibrium, about which the conventional wisdom is silent, involves adverse selection.

The key empirical feature of an adverse-selection equilibrium is that one borrower type is indifferent between the available mortgage contracts, while the other type strictly prefers one contract. In other words, the market trade-off between i_0 and i_1 is the same as the trade-off along an indifference curve for one borrower type, while the other borrower's curve exhibits either a steeper or flatter trade-off (see Fig. 2). By contrast, an equilibrium inconsistent with adverse selection would have both borrower types *strictly preferring* their chosen contract.

A crude attempt to test for adverse selection might proceed as follows. First, let the utility function V be represented by a linear approximation, so that the MRS in (2) is equal to $1/\delta(1 - \rho)$. Then, as in the model, suppose there were just two borrower types, with ρ_l and ρ_h estimated by PROBMOVE values of 0.2234 and 0.3574, which lie one standard deviation above and below the sample mean of 0.2904. To evaluate the MRSs for these two hypothetical borrowers, the discount factor δ can be estimated via a probit procedure.[15] This gives a value of 15.8, which yields $\text{MRS}_l = 0.081$ and $\text{MRS}_h = 0.098$.

The results of Table II indicate the trade-off between i_1 and i_0 available in the market, to which these MRSs can be compared. The estimate in the first line of the table implies that the market trade-off occurs at a rate of 0.082.[16] Comparing this value to the MRS figures from above, it is clear that the low-mobility borrower is almost exactly indifferent among choices from the available points/interest-rate menu ($0.081 \approx 0.082$). The MRS of the high-mobility borrower, however, is greater than the slope of this menu ($0.098 > 0.082$). This suggests an outcome like that in the lower half of Fig. 2, where the type-l borrower is indifferent between contracts J and K, while the type-h indifference curve is steeper than the line segment connecting J and K.

While these results seem consistent with the presence of adverse selection, they are at best suggestive. The main problem, of course, is that to match the model, the actual continuum of borrowers is collapsed to just two mobility types, whose ρ values are then arbitrarily chosen. Construction of a proper test for adverse selection would require a model with a large number of borrower types and the adoption of empirical procedures consistent with it.[17]

4. CONCLUSION

This paper has analyzed a simple mobility-based model of mortgage lending with asymmetric information and has used the results to illumi-

[15] To estimate δ, mortgage contracts are divided into high-points and low-points categories as in Table II, and a probit equation is estimated using PROBMOVE as the explanatory variable. One equation is estimated for each of the high-points definitions in Table II, and the δ estimates are then averaged. The resulting δ value of 15.8 is large because the model collapses the entire future into a single period. Details are available on request.

[16] Table II shows that a 100-basis-point increase in POINTS reduces the interest rate by 7.58 basis points. It follows that a 7.58 decrease in t is associated with a $92.42 = 100 - 7.58$ increase in $t + p$, implying a trade-off between i_1 and i_0 at a rate of $0.082 = 7.58/92.42$.

[17] For an attempt to test for adverse selection in insurance markets, see Puelz and Snow (1994).

nate the issue of mortgage points. The analysis suggests that by offering a points/interest-rate menu, lenders are able to induce borrower self-selection across mortgage contracts according to unobserved mobility. The self-selection implied by the model conforms to conventional wisdom, with mobile borrowers choosing low-points/high-rate contracts from the available menu. As in other adverse-selection models, separation of the borrower types is achieved at a cost: welfare is reduced relative to the full-information case. The analysis shows that this cost can be borne by either borrower type (high-mobility or low-mobility) depending on parameter values. Finally, the analysis shows that a prepayment penalty is not a perfect substitute for mortgage points in the presence of adverse selection. Introduction of such a penalty either lowers or raises welfare, depending on the characteristics of the mortgage market equilibrium.

The empirical results show that a points/interest-rate trade-off is present in the data and that borrowers select contracts from this menu in the expected fashion according to mobility. In addition, the results appear to be consistent with the presence of adverse selection, although this conclusion is highly tentative.

This paper may help improve our understanding of the role of borrower mobility and asymmetric information in the mortgage market. Further research exploring the effects of both these factors on the structure of mortgage contracts deserves high priority.

APPENDIX

First, it is shown that introduction of the prepayment penalty has no effect on the welfare of the type-l borrower. Using the modified version of (1), the change expected utility is equal to

$$-(1-\rho_l)\left[V'(y-i_0^{\mathrm{K}})\frac{\partial i_0^{\mathrm{K}}}{\partial s}+\delta V'(y-i_1^{\mathrm{K}})\frac{\partial i_1^{\mathrm{K}}}{\partial s}\right]$$

$$-\rho_l V'(y-i_0^{\mathrm{K}}-s)\left[1+\frac{\partial i_0^{\mathrm{K}}}{\partial s}\right]. \tag{a1}$$

Substituting from (8) and evaluating at $s=0$, (a1) reduces to zero.

To derive the impact of the prepayment penalty on the type-h contract, the following equations are differentiated:

$$(1-\rho_l)[V(y-i_0^{\mathrm{J}})+\delta V(y-i_1^{\mathrm{J}})]+\rho_l V(y-i_0^{\mathrm{J}}-s)=\text{constant} \tag{a2}$$

$$i_1^{\mathrm{J}}=r_1+\frac{r_0-i_0^{\mathrm{J}}-\rho_h s}{\theta(1-\rho_h)}. \tag{a3}$$

Equation (a3) is the zero-profit condition (the type-h locus is now relevant), and (a2) is the adverse-selection condition discussed in the text. Differentiation of (a2) and (a3) yields the impacts

$$\frac{\partial i_1^{\mathrm{J}}}{\partial s} = Z[(\rho_l - \rho_h)V'(y - i_0^{\mathrm{J}})] > 0, \tag{a4}$$

$$\frac{\partial i_0^{\mathrm{J}}}{\partial s} = Z[\delta\rho_h(1 - \rho_l)V'(y - i_1^{\mathrm{J}}) - \theta(1 - \rho_h)\rho_l V'(y - i_0^{\mathrm{J}})] > (<)\ 0, \tag{a5}$$

where

$$Z = [\theta(1 - \rho_h)V'(y - i_0^{\mathrm{J}}) - \delta(1 - \rho_l)V'(y - i_1^{\mathrm{J}})]^{-1} < 0. \tag{a6}$$

To verify that Z has a negative sign, observe that since the type-h indifference curve is flatter than the zero-profit locus at J, $V'(y - i_0^{\mathrm{J}})/\delta(1 - \rho_h)V'(y - i_1^{\mathrm{J}}) < 1/\theta(1 - \rho_h)$ holds (see (2)), implying $\theta V'(y - i_0^{\mathrm{J}}) < \delta V'(y - i_1^{\mathrm{J}})$. Given $(1 - \rho_h) < (1 - \rho_l)$, Z is then negative, and the positive sign of $\partial i_1^{\mathrm{J}}/\partial s$ in (a4) follows by inspection. Manipulation of (a4) and (a5) establishes $\partial(i_0^{\mathrm{J}} - i_1^{\mathrm{J}})/\partial s < 0$.

To compute the welfare impact on the type-h borrower, an expression analogous to (a1) is evaluated (ρ_l is replaced by ρ_h, and the K subscripts are replaced by J). Substituting the results from (a4) and (a5), and welfare impact simplifies to

$$-Z(1 - \rho_h)(\rho_h - \rho_l)V'(y - i_0^{\mathrm{J}})[\theta V'(y - i_0^{\mathrm{J}}) - \delta V'(y - i_1^{\mathrm{J}})] < 0, \tag{a7}$$

where the inequality follows from previous results. Thus, introduction of the prepayment penalty *reduces* expected utility for the type-h borrower.

Now suppose the tangencies are above Q and the type-l borrower is the one hurt by adverse selection. In this case, the contracts are relabeled A and F, as in Fig. 2, and the h and l subscripts change places in the analysis. In addition, since the indifference curve at F is steeper than the zero-profit locus, the sign of Z changes to positive, and the term analogous to the one in brackets in (a7) also becomes positive. The welfare effect based on the analog to (a7) is then *positive* instead of negative.

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