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HOUSING APPRAISALS AND REDLINING

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ABSTRACT

We develop a model of a mortgage market which captures the dynamic information gathering which is implied by the use of home appraisals. In our model, the precision of appraisals depends on the quantity of previous home sales. In turn, the precision of appraisals influences current home sales, since when appraisals are inaccurate, lenders require larger down payments. There is thus a dynamic information externality in which past purchases influence current purchases. As a consequence, differential mortgage lending behavior will be sub-optimal, and the appearance of redlining may be justifiably subject to corrective action.

Introduction

When mortgage makers make loans, they rely on appraisals, either formal or informal, to determine whether the price paid in the transaction under consideration is a reasonable one. In neighborhoods where transactions occur infrequently, there is likely to be more noise contained in the appraisal. This greater uncertainty about home valuation leads mortgage lenders to place more stringent requirements, here modeled as larger down payments, on loans in these neighborhoods. In a competitive mortgage market, the informational gains produced by a high number of transactions are not captured by individual agents. This mechanism may provide an economic rationale for sub-optimal differentials in mortgage lending behavior across neighborhoods as well as the perception that mortgage lenders engage in the practice of "redlining".

The possibility that certain neighborhoods are systematically denied credit has been a long-standing public policy concern. The lack of available credit is often cited as a causal factor in neighborhood deterioration. Banks have been accused of practicing "redlining", a practice of delineating neighborhoods within which no loans will be granted. More generally, the term redlining has been used to denote discriminatory practices in the mortgage lending market.

Combatting these alleged discriminatory practices has been an avowed public policy goal for over thirty years. Yet despite various laws and regulations, such as the Community Reinvestment Act of 1977, many community activists have maintained that banks continue practicing discrimination in mortgage lending.

Several recent empirical studies, most notably Bradbury, Case and Dunham (1989), have shown that banks do indeed make fewer mortgage loans in

predominantly minority neighborhoods even after controlling for median family income, the number of single-family homes and the median price of single-family homes. These studies have been cited as evidence that lenders are discriminating.

However, the evidence in these studies is not conclusive proof of discrimination. The observed differences in lending behavior might be explained by economic factors which are not easily measured or controlled for in empirical studies. While median home prices and income are easily measured, other variables which affect the default risk of a mortgage loan are more difficult to quantify. For example, an important component of default risk is the stability of real estate values in a neighborhood. There is evidence that the risk of large housing price declines is significantly greater in predominantly minority neighborhoods.[1]

However, even if there is an economic basis for differential lending behavior, these differentials may not be optimal. In this paper the term "redlining" is used to refer to differentials in mortgage loan supply across neighborhoods which are sub-optimal. Our model provides a purely economic rationale for (socially) sub-optimal differentials in mortgage markets, even though mortgage lenders are assumed to be profit maximizers who do not behave on the basis of racial or ethnic prejudice.[2] The appearance of discrimination, whether due to prejudice or to rational economic decisions, may thus be justifiably subject to corrective action.

A different model of rational redlining is presented by Guttentag and Wachter (1980). Their model rests on neighborhood effects in which improvements in one property in a neighborhood can increase the value of other properties in the neighborhood -- rather than information. Our model of

appraisals is based on Quan and Quigley (1990).

A Model of Mortgage Loans

Mortgage lenders are assumed to be competitive and risk neutral with a discount rate of β. Lenders equate the expected present discounted value of the loan (including the foreclosed value of the property if there is a default). It is assumed that a lender charges the same interest rate on its mortgage loans in all neighborhoods.[3] Lenders decide on the maximum size of the loan, L_{jt}, given the estimated value of the real estate and the wealth and income of the borrower.

We assume the following pricing model for owner occupied housing:

$$x_{jt} = x_t + \epsilon_{jt} \tag{1}$$

x_t should be thought of as the average market price for the neighborhood, while ϵ_{jt} is a random noise contained in the bargaining process over the particular property labeled j at time t. The buyer and seller are presumed to know the value of x_t.[4] However, the proposed transaction price x_{jt} may depend on the buyer's idiosyncratic preferences, the relative impatience of the buyer and seller as well as other factors.[5] For simplicity, it is assumed that x_t follows a random walk.

$$x_t = x_{t-1} + \eta_t \tag{2}$$

The average value of the house will depend on the expected present discounted value of the future imputed rental service flows of the house. Changes in x_t, the η_t, reflect changes in the expected service flows. ϵ_{jt} and η_t are assumed to be independent, normally distributed, mean-zero random variables.

Lenders obtain an appraisal of the house which contains information from

all past completed transactions in the neighborhood. The optimal appraisal and its variance can be readily computed using the Kalman filter, and is the best estimate of x_t given information available at time t-1. We designate optimal appraisal as $\mu_{t|t-1}$. As we shall show below, the precision of this appraisal depends on the number of completed transactions N_{t-i}, for all $i \geq 1$.

An individual lender observes x_{jt}, the transactions price of one house, at the beginning of period t and combines this with the appraisal to infer the value of x_t[6]. The lender then sets the loan size L_t, which in turn determines the down payment which the buyer must make. The larger the average required down payment, the fewer the number of transactions will be completed.

At the end of period t, appraisers learn the values of x_{jt} for all completed transactions in the area.[7] Borrowers are assumed to have the same non-stochastic and observable current and future labor income.[8]

What is crucial to the model is that there is some information about the underlying values of homes which lenders are only able to obtain by observing actual transactions. Because this information is noisy, the more transactions that occur, the more precisely lenders are able to value homes.

The underlying value of homes is determined by the degree of local amenities, the efficiency of local government, the vitality of local businesses, the availability and conditions of roads and mass transit, and so forth. Local residents observe much of this value directly, by living in the community. Outsiders, such as lenders, observe it indirectly, by observing transactions.

We assume that lenders cannot learn this information by asking local residents because local residents share an interest in a high valuation of local homes, although we do not model this explicitly.

Optimal Appraisals

How is the optimal appraisal calculated at time t-1? Using the Kalman filter, the updating equation for the optimal appraisal is:

$$\mu_{t|t-1} = \mu_{t-1|t-2} + \alpha_{t-1}(m_{t-1} - \mu_{t-1|t-2}) \tag{3}$$

Where

$$m_{t-1} = \sum_{j} x_{jt-1}/N_{t-1}$$

$$\alpha_{t-1} = s_{t-1}/(\sigma_\epsilon + N_{t-1}s_{t-1})$$

$$s_{t-1} = \sigma_\epsilon\alpha_{t-2} + \sigma_\eta \tag{4}$$

Here $\mu_{t|t-1}$ is the optimal appraisal of house price at time t based on transactions through the end of period t-1, m_{t-1} is the average price of houses sold in period t-1, and s_{t-1} measures the variance of the optimal appraisal. When the number of transactions at time t-1, N_{t-1}, is higher, then the variance is reduced: with more data, the underlying value of houses in the neighborhood can be estimated with greater certainty.

The marginal effect on s_{t-1} of an increase in N_{t-1} falls with the level of N_{t-1}. That is to say, the marginal gain in appraisal precision from increasing lending activity will be greatest in thin markets.

Lender's Estimate of x_t

The lender's information set includes x_{jt}, the appraisal, $\mu_{t|t-1}$ and the appraisal's variance, s_{t-1}. The proposed transaction contains information which is used by the lender to update the appraisal. Let

$$\mu_{t|t} = E(x_t|x_{jt}, I_{t-1})$$

$$s_{t|t} = E[(x_t - \mu_{t|t})^2|x_{jt}, I_{t-1}]$$

The minimum mean squared error estimators would give

$$\mu_{t|t} = \mu_{t|t-1} + \gamma_t(x_{jt} - \mu_{t|t-1}) \tag{5}$$

Where $\gamma_t = s_{t-1}/(\sigma_\epsilon + s_{t-1})$

$$s_{t|t} = \sigma_\epsilon\gamma_t + \sigma_\eta \tag{6}$$

Equation 3 is the lender's best guess of the underlying value of the house, which includes knowledge of the sale value of the house being appraised.

Equation 4 gives the estimation error variance.

The Borrower's Default Decision

A borrower defaults on the loan if $x_t + A < L_t$ where L_t is the outstanding principal of the loan. A is the minimum of the borrower's costs of bankruptcy or the borrowers' non-human capital (excluding the value of the property). A is assumed to be nonnegative and constant over time. The loan gives the borrower a put on the house, which the borrower exercises rationally, given the impairment to the borrower's credit which arises from the default.[9].

Equilibrium Redlining

The expected value to the lender for a traditional fixed rate mortgage loan[10] can be written as:

$$V_t = E_t \Sigma \beta^i P_{t+i}S_{t+i} \tag{7}$$

$$where\ S_{t+i} = \begin{cases} 1 & if\ x_{t+j} > L_{t+j} - A\ ;\ 0 < j < i \\ 0 & otherwise \end{cases}$$

$$P_{t+i} = \begin{cases} P(r_t, L_t) & \text{if } x_{t+i} > L_{t+i} - A \\ x_{t+i} & \text{otherwise} \end{cases}$$

$P(r_t, L_t)$ is the fixed mortgage payment which depends on the interest rate (r_t) and the size of the initial loan. The mortgage loan provides an option value to the borrower. The borrower can essentially sell back the property to the bank at time t+i at the price of L_{t+i} - A. Consequently, the value of the mortgage to the lender (V_t) is a decreasing function of the variance of the forecast errors of x_t along with the idiosyncratic variance - (ϵ_t).

It is easy to show that the forecast error variance at time t for future periods will be an increasing function of the estimation error variance for x_t. The estimation error variance for x_t is $s_{t|t}$ which depends on s_{t-1}, σ_ϵ and σ_η. The last two terms are exogenous, but s_{t-1} depends positively on $s_{t-1|t-2}$ and N_{t-1} (the number of loans in that neighborhood).[11]

That is to say, the level of risk associated with mortgage lending in an area is related to the exogenous risk parameters (σ_ϵ and σ_η) and to the level of lending in the past. To control this risk, a mortgage lender offering mortgage loans with a given fixed rate of interest will require a larger downpayment in neighborhoods with higher risk. Other things equal, larger downpayments will reduce the probability that a given transaction will be completed, decreasing the quantity of loans actually made in a given period. In the static equilibrium being discussed here, the uncertainty associated with appraisals, s_{t-1}, is negatively related to the number of loans completed, N_t.

Different neighborhoods will be characterized by different values of

σ_η[12]. Neighborhoods with higher values of σ_η will tend to have lower levels of mortgage lending. Moreover, while differences in σ_η would lead to differences in lending in a first best allocation, the endogenous information generating process tends to widen these differences. The total gain from increased market activity is not captured by competitive lenders. This externality exists in all markets, but in markets which are thin this externality becomes more important.

Persistence and Multiple Equilibria

If there is a one-time increase in the underlying uncertainty parameters, this will decrease the quantity of loans to the neighborhood. A thinner loan market will in turn make future loans riskier and this will in turn decrease the quantity of loans further. Thus a serially uncorrelated adverse shock will on average lead to a protracted decline in mortgage lending activity. Further, there will in general be more than one stationary value of N (the number of loans).

To see this, substitute the expression for α_{t-1} above equation 4 into equation 4, and update to obtain an expression for s_t:

$$s_t = \sigma_N + \sigma_\epsilon s_{t-1}/(\sigma_\epsilon + N_{t-1}s_{t-1}) \qquad (8)$$

Equation (8) is a non-linear first-order difference equation with a time dependent parameter -- N_{t-1}. For a constant N, this linear difference equation is stable and asymptotically approaches a steady state value for s. Define the relationship between stationary values for N and s as:

$$N^* = \psi(s^*) \quad ; \ \psi' < 0 \qquad (9)$$

In the static equilibrium, the volume of loans (N_t) is negatively related to the forecast error variance of the market price of real estate (s_{t-1}). Writing this relationship as:

$$N_t = f(s_{t-1}); \qquad f' < 0 \tag{10}$$

Stationary points for N and s occur at the intersection of the f and ψ curves (see Figure 1). In general, there are at least two such crossings since the slope of the ψ curve asymptotically approaches the N and s axes [see equation (8) for constant N and s]. However, it is possible to have additional crossings. Local stability of a stationary point requires that the f curve be flatter than the ψ curve. Thus point E_0 in Figure 1 is locally stable while point E_1 is unstable.

If the market is in an initial equilibrium at E_0, then a one-time adverse shock is a movement to the southeast along the f curve. If the shock is small enough ($N > N_1^*$), then the market slowly returns to the original stationary state. If the shock is sufficiently large to push N below N_1^*, the N would move toward a lower stationary level of N or to 0.[13] Note that N = 0, corresponding to no mortgage loans being made in the area, is a possible long run equilibrium with s increasing by σ_η each period.

To summarize, a serially uncorrelated adverse shock which lowers N will lead either to a persistent decline in N with an eventual return to the original steady state or to a movement to a permanently lower value of N. Because of the existence in multiple steady state equilibria, relatively small differences in the underlying parameters of the model can have potentially large implications for the path of loan activity.

Social Welfare

In any period t, an increase in the number of transactions N_t increases the precision with which the variable x_{t+1} is estimated. This reduces the size of the down payment required of all borrowers at time t+1 and all later periods. This benefits all existing homeowners, who are more likely to be able to sell their homes, and future potential home buyers who will be more able to buy homes. Thus a small subsidy to borrowers (in a form which reduces their down payment) always improves welfare. This subsidy could be partially paid for by a tax on existing homeowners; however some of the benefits go to future home buyers who may not exist yet and cannot be taxed.

As discussed above, the welfare improvement from subsidizing lending is likely to be greater in thinner markets. Programs such as those adopted by banks to comply with the Community Reinvestment Act of 1977 can help ameliorate the impact of information externalities in thin mortgage markets and may well improve welfare. To emphasize the most important point, the appearance of discrimination, even though this is the result of disinterested competitive profit maximization, could be socially sub-optimal and subject to correction by subsidy.

In addition, given that there are in general multiple steady states and that initial conditions matter, a prior history of discrimination in a locality may lead to differential market behavior which persists even though the discriminatory practices have been eliminated. A minority group may be disadvantaged by the persistent effects of past discrimination.

Local banks

We have assumed that lenders' knowledge of past prices of real estate transactions is costless. Suppose we relax this assumption, and assume that only local mortgage makers are able to gather this information, and that staying in the market involves a fixed cost which is amortized in mortgages.

First, note that as the number of mortgages shrinks, the local mortgage makers must either leave the neighborhood or charge more per mortgage to amortize the fixed cost. In a static model, as in Gruben, Neuberger and Schmidt (1990), the pareto optimal level of mortgages falls reflecting the higher per mortgage cost of local information. However, in a dynamic setting with informational externalities, these costs exacerbate the negative link between the volume of loans and forecast error variance described in equation (10).

If there are few local mortgage makers, as is likely if information externalities are a problem, these local mortgage makers may have market power. This market power helps a mortgage maker to internalize some of the information externality. By subsidizing some mortgage loans, a mortgage maker gains additional information which it may be able to use in subsequent periods when it can use its market power to earn additional profits.

However, a local mortgage maker with market power may suffer a decline in capital when there is a negative shock in the local mortgage market. This decline in capital may force the mortgage maker to reduce new lending, even though there are profitable lending opportunities, if the mortgage maker has impaired access to capital markets (due to asymmetric information). This again would exacerbate the redlining problems which we have discussed.

Thus while a local mortgage maker may -- because of market power --

partially resolve the informational externality, it is also possible that the existence of local mortgage information and power may exacerbate the effect of a negative shock to the local mortgage market.

Summary

We have set forth a model of mortgage lending in which increased uncertainty about the underlying value of housing is costly because it causes lenders to seek larger down payments, and borrowers are capital constrained. Under the assumption that fewer transactions lead to increased uncertainty about home valuation, lending is undersupplied, and this undersupply is most pronounced in thin mortgage markets.

Given that the model is characterized by multiple long run steady states, so that prejudicial practices of the past may lead to continued differentials in lending behavior. Governmental programs which ameliorate these differences, such as programs which subsidize borrowing in thin mortgage markets (if carefully designed) may improve welfare.

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NOTES

1. Avery and Buynak (1981).

2. This is not to say that such biases do not exist, but rather to concentrate on purely economic issues which are relevant to the problem.

3. It is assumed that mortgage lenders do not tailor interest rates on mortgage loans based on idiosyncratic characteristics of the neighborhood. This assumption reduces the complexity of the model, but is not crucial for the results. The crucial issue for our results is that either loan size will be reduced or interest rates will rise when mortgages are riskier.

4. What is crucial is that buyers and sellers have more information than outside lenders and that the agreed-upon price contains additional information about x_t but doesn't fully reveal x_t.

5. In Quan and Quigley, borrowers do not know x_t. We could adopt this hypothesis; then default by borrowers would depend on the expected value of x_t. This leads to a slightly more complex default rule by borrowers, because there is additional noise in the option value of default.

6. The estimate of x_t would be the same if the lender generates the estimate directly from x_{jt} and the past history of prices, because the appraisal and its variance represent sufficient statistics for the past data.

7. Alternatively, it could be assumed without changing the results that lenders' only observe the x_{jt}'s for those transactions that are completed. Formally, this would lead to non-homogeneous information sets across lenders at the end of the period.

8. This assumption can be relaxed without affecting the main results of the paper.

9. An alternative model of default would be one in which the borrower's income is stochastic and there is some probability that the borrower cannot pay off the loan. If this occurs and the sale price of the house is sufficiently low relative to the loan, then default occurs. In this case as well, the value of the loan to the mortgage lender will be inversely related to the variance of the market price of the property.

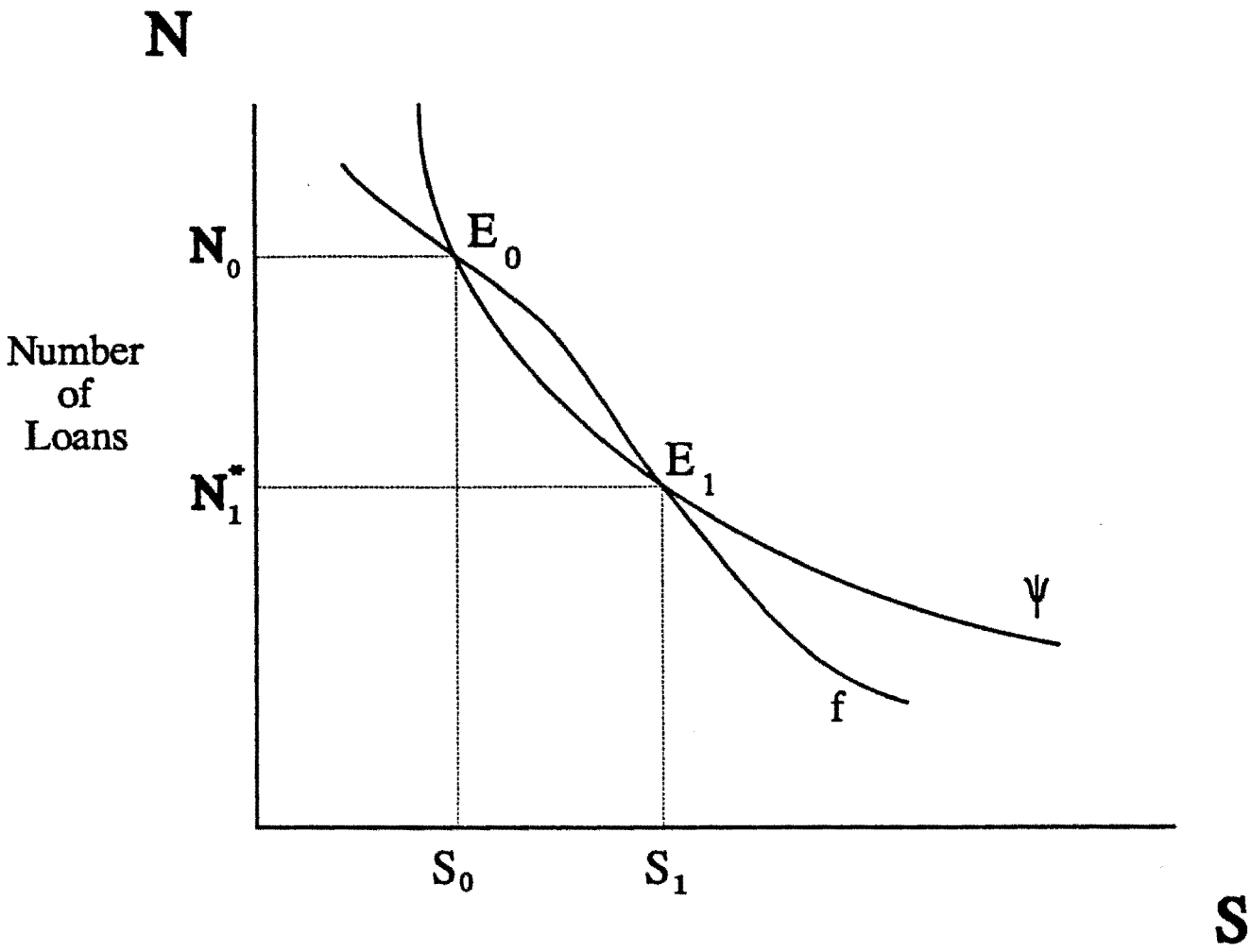
10. The central argument applies intact to more complicated mortgage loans, but to simplify formulas we have concentrated on the traditional fixed payment mortgages.

11. We are assuming that all real estate transactions are loan-financed. As long as the total number of real estate transactions is positively correlated with the number of loan-financed transactions, our results will hold.

12. Different neighborhoods may well have common shocks as well as idiosyncratic ones. There is no essential difference. A common negative shock (such as a rise in the interest rate π) reduces lending in all mortgage markets, and thus sales, and reduces the precision of information of all home

values. Common shocks are explicitly modeled in a somewhat different context in Lang and Nakamura (1990).

13. If the adverse shock displays positive serial correlation, then the market can be pushed to a new stationary steady state value of N even if the initial value of N is greater than N_1^*.



Variance of
Home Appraisals

Figure 1

Multiple Equilibria In
Mortgage Loan Market