The Price of Protection*
Theory and Evidence on Foreclosure Law, Mortgages and House Prices

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The Price of Protection

Abstract

We study the effect of foreclosure laws on house prices. We develop a dynamic general equilibrium model in which defaulter-friendly foreclosure laws exacerbate downpayment requirements; this effect lowers the aggregate demand for housing and thus decreases equilibrium house prices. We test this hypothesis by comparing house prices in nearby census tracts along state borders. Houses that are geographically close to each other (but lie in different states) will largely share unobserved factors affecting house prices, but are subject to different foreclosure laws. We formalize this intuition by specifying a semiparametric model in which the nonparametric component captures all factors that vary smoothly over space. Because the laws change discontinuously at the state border, their effect is still identified. As predicted by our model, defaulter-friendly foreclosure laws lower house prices by between 2.5 and 5 percent.

Journal of Economic Literature classification numbers: G21, K11, D18, D82.
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1 Introduction

Foreclosure laws govern the rights of lenders and borrowers when borrowers default on mortgages. These laws differ significantly across states: in some states the laws allow lenders to evict defaulting borrowers quickly, while in others they provide numerous protections for defaulters. Empirically, these defaulter-friendly laws are associated with higher lender losses, higher interest rates and smaller loan sizes.\footnote{For evidence on lender losses see Ciochetti (1997), Clauretie (1989), Clauretie and Herzog (1990), and Wood (1997). For evidence on higher interest rates, see Alston (1984) and Meador (1982); and for evidence on loan sizes, see Pence (2003a).}

Foreclosure laws can also exacerbate the moral hazard inherent in mortgage contracts. Until a mortgage is paid off, the tenant-borrower shares ownership rights with the lender: if the house falls in value, the borrower can give it back to the lender, escaping some of the cost. In our model, the value of the house depends in part on unobserved effort that homeowners put into maintaining their properties. When the occupier of a property does not have full ownership rights, she is likely to underinvest in maintenance.\footnote{Renters, for example, are generally considered to invest less in maintenance than homeowners; see Henderson and Ioannides (1983) and the large subsequent literature.} In a state where the foreclosure laws are generous – and the benefits of defaulting greater – the borrower’s incentive to maintain the property is lower still.

Creditors respond to these lower incentives by charging higher mortgage rates. However, higher mortgage rates also decrease the incentive to exert maintenance effort. Borrowers can only escape this self-reinforcing trap by putting up a larger
downpayment. Households with low current income but high permanent income (for example, young households or households recovering from a bad economic shock) may not be able afford a sufficient downpayment. As a result, they may be credit rationed, that is, unable to borrow sufficient funds to finance the purchase of a large enough house. More defaulter-friendly foreclosure laws will only increase the minimum downpayment requirement, resulting in more credit-rationed households. The aggregate demand curve for housing will, as a result, shift down as foreclosure laws become more defaulter-friendly. This effect lowers equilibrium house prices.

A large literature has demonstrated the effect of downpayment constraints on home ownership and in turn on consumption and saving, house price volatility, house trading volume and time-to-sale.3 Fewer papers, however, have traced the origins of these downpayment constraints. This paper begins to fill this gap.4

We test empirically our model’s implication that house prices should be lower in states with defaulter-friendly foreclosure laws. Foreclosure laws vary across regions of the country, but so do a myriad of other factors that affect house prices. For example, a cross-sectional study based on nationwide data from the mid-1980s would note low house prices in Texas (a state with lender-friendly laws) and high house prices in New York (a state with defaulter-friendly laws). Part of this difference in house prices, though, is due to the mid-1980s collapse in the Texas oil industry. Without controlling adequately for observed and unobserved regional

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4But see Ortalo-Magné and Rady (1999, 2002) for other approaches to this problem.
variation in factors other than laws affecting house prices, one risks confounding the effects of laws with the effects of these other regional variables.

To disentangle these factors, we examine median house prices in census tracts along state borders. Because these census tracts are near each other, they are likely to take on similar values of variables that influence house prices; because they are in different states, they are subject to different foreclosure law regimes. We formalize this intuition through a partial linear model in which the nonparametric component soaks up unobserved factors that vary with geographic location. Because this nonparametric component takes on a different value at each census tract, it captures in a flexible manner the local amenities and shocks, such as access to water or layoffs at a major employer, that influence house prices. As long as these unobserved factors change continuously over space, while state laws change discontinuously at state borders, the effects of both the laws and the unobserved factors can be identified.

We estimate this model over two samples. The first, which we refer to as the city sample, consists of 12,000 census tracts in 55 metropolitan statistical areas that span state lines. Unobserved variables are likely to take on similar values within each city because houses within an MSA, or housing market, are at least possible substitutes for each other. The second sample, which we refer to as the national sample, consists of all 58,000 census tracts in the continental United States. By including the entire United States, we mitigate any concerns that the MSAs in the first sample are not representative. In addition, although census tracts away from the border do not help identify the effects of foreclosure laws directly,
they may sharpen the estimates of other covariates in the model that are correlated with foreclosure laws.

Results from the city sample suggest that defaulter-friendly foreclosure laws decrease house prices by about 5 percent. Results from the national sample are slightly weaker, with defaulter-friendly foreclosure laws decreasing house prices by about 2.5 to 3 percent. Nonetheless, both sets of results are statistically and economically significant.

Our results do not necessarily argue for eliminating foreclosure protections, because agents in our model do not need any insurance against income risk or other economic shocks. Laws that limit the rights of creditors, such as foreclosure laws, provide a crude form of insurance, allowing households to smooth consumption through these periods of economic stress. However, our theory suggests that foreclosure laws affect house prices primarily by credit rationing the poorest home buyers. Thus the decrease in house prices associated with defaulter-friendly foreclosure laws does not make housing more affordable.

Instead, our results provide empirical evidence of the effect of agency costs on equilibrium consumer lending terms. Most models with incomplete contracts (whether because of moral hazard, adverse selection, or some other agency problem) depend crucially on parameters that are very hard to measure. In this paper we establish a tight link between the theoretical concept that determines how

\footnote{In the realm of unsecured debt, Lehnert and Maki (2002) find that consumer bankruptcy protections do provide some consumption insurance, suggesting that, in the absence of other forms of consumption insurance, exempting some assets from seizure improves social welfare despite the increased deadweight costs.}
tightly the incentive-compatibility constraint binds and actual foreclosure laws.\textsuperscript{6} Thus we are in the position of testing the empirical relevance of agency costs. Because we find that these costs are significant, models of consumer lending that do not feature some form of agency friction are of questionable relevance.

2 Foreclosure Law and House Prices: Theory

Overview

In this section we sketch out how the interaction between foreclosure laws and the incentives inherent in a mortgage contract can affect house prices. We provide a fuller theoretical treatment of the model in appendix A.

Our model is based on the effect of debt financing with default on incentives; in particular, on the incentive to maintain a house. If homeowners could not default on their mortgages, so that they absorbed fully the costs and benefits of maintaining their property, there would be no incentive problem and they would expend the optimal quantity of maintenance effort. By contrast, as homeowners become more leveraged, they bear less of the costs of poor maintenance because, if their property values decline too much, they can default on their mortgages. In the extreme case renters, who by definition bear almost none of the price risk, have almost no incentive to maintain their property.

The incentive problem at the heart of our model is (in some form) quite com-

\textsuperscript{6}In the context of capital reallocation, Eisfeldt and Rampini (2003) also use observables to pin down an unobserved agency parameter.
mon in the literature. As many authors in a variety of fields have recognized, the user of a durable good will have different incentives from the good’s owner. In Henderson and Ioannides (1983), for example, landlords cannot control the intensity with which renters use their property. In this paper, we use a slightly different formal convention; we follow the mechanism design literature and specify that tenants (whether owners or renters) exert unobserved labor effort.

We explicitly identify this unobserved effort as direct maintenance of the property. Keeping a house in good condition requires continuous vigilance and a myriad of small repairs. However, the “effort” in our model may be thought of more broadly; for example, homeowners may be more engaged in local government decisions, paying more attention to, and voting on, initiatives that affect school quality and other neighborhood attributes. Several studies have concluded that homeownership has external social benefits; in part, these benefits may be the result of homeowners expending more effort on maintaining the social fabric of their local community.\(^7\)

Our model fits neatly into a principal-agent framework, with tenants in the role of agents and lenders (and landlords) in the role of principals. Contracts, in this case either rental contracts or mortgages, will have to satisfy an incentive compatibility constraint.\(^8\) As is typical in principal-agent problems, protecting the agent from the consequences of his actions worsens his incentive to maintain

\(^7\)The literature on the social benefits of homeownership is vast; see Haurin, Parcel, and Haurin (2002) for a representative study and Dietz, Haurin, and Weinberg (2003) for a survey.

\(^8\)For a readable introduction to this modelling framework, see Sappington (1983). Prescott and Townsend (1984a,b) provide several very general results.
the property. Indeed, Harding, Miceli, and Sirmans (2000) find evidence in the American Housing Survey that physical maintenance expenditures are lower in states with defaulter-friendly foreclosure laws. In our model, families (the agents) with high loan-to-value ratios will be more likely to default on their mortgages, and, as a result, face less of the risk to the value of their house. They will exert less effort to maintain the house and the house will be more likely to decline in value. Lenders (the principals) realize this and charge increasing credit spreads to those families.

Foreclosure law, in our model, will exacerbate the incentive problem of high loan-to-value ratios. We model foreclosure law as the length of time that a homeowner can expect to stay in his house after defaulting on the mortgage. More formally, in our model defaulters face a constant probability \( 1 - k \) of being evicted each period. The larger \( k \) is (i.e. the more “defaulter-friendly” the law) the greater the incentive to default on the mortgage, all else equal. Of course, lenders take this into account when setting loan terms, so borrowers may face increased credit spreads in reaction to the law.

However, by increasing the credit spread on mortgage debt, lenders also decrease the incentive for households to exert effort on maintenance, thus increasing the probability of default. Increasing credit spreads raises the expected revenue of lenders only to a point; beyond some level expected revenues actually decrease in the interest rate on the loan. Households who want larger loans are unable to obtain them.

Because having a high loan-to-value ratio increases the credit spread charged
on the mortgage, and thus the user cost of housing, in our model families will seek to make relatively large downpayments. Poor families may not have enough liquid assets to make a sufficiently large downpayment to satisfy lenders. These families are downpayment constrained.

Relatively poor, downpayment-constrained families are rationed away from their first choice of housing. More households may be rationed in this fashion the more defaulter-friendly the foreclosure law. The result is that foreclosure law decreases the demand schedule for housing. In equilibrium, this in turn guarantees lower house prices. House prices will be especially sensitive to foreclosure laws in economies in which many households are downpayment-constrained.

Model

Agents have one-period felicity functions over housing consumption, \( h \), non-housing consumption, \( c \), and maintenance effort \( z \) given by:

\[
(1) \quad u(c, h, z) = \sigma \log(h) + c - \frac{1}{2\alpha} z^2; \quad c \geq 0, \quad h > 0, \quad 0 \leq z \leq 1.
\]

This log-linear specification has two main benefits: first, it allows us to abstract from households’ preference for smooth non-housing consumption (across states or dates); and, second, households will want to spend a constant amount (price times quantity) on housing services. With the felicity function (1), households

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\(^9\)In our model families do not want to smooth their consumption of non-housing goods over time.
will order sequences of consumption, housing and effort as:

$$U \left( \{ c_t, h_t, z_t \}_{t=0}^{\infty} \right) = \sum_{t=0}^{\infty} \beta^t \left[ \log (h_t) + c_t + z_t^2 (2\alpha)^{-1} \right].$$

Here the discount factor $\beta$ is the product of the true psychological discount factor $\eta$ and the probability of surviving into the next period, $\lambda$.

Given the constant hazard of death, a proportion $1 - \lambda$ of agents will be newly-born each period to replenish the population. Each “young” agent $j$ will have an initial non-housing endowment of $Y_0^j$. In the next period (their second period of life) these agents will graduate to their adult permanent income, $Y = nY_0^j$, where $n > 1$. Agents will differ in their endowment streams. Permanent incomes $Y^j$ are distributed with a known, constant distribution function $F(Y)$. Endowments lie in the closed interval $[\underline{Y}, \overline{Y}]$. An agent of type $j$ receives the endowment $Y^j$ each period of life (after the first) with certainty. For simplicity, we will concentrate on lending to young agents; from the second period of life, we will assume that agents do not face liquidity constraints of any kind and have access to perfect capital markets.  

At the beginning of a period an agent inherits a stock of housing from the previous period; the agent then has an opportunity to costlessly change that housing stock at the period’s equilibrium price of housing, $P_t$. Once he has decided how much housing to occupy, the will occupy this housing “overnight” into the next period.

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$^{10}$The incentive compatibility constraint on maintenance effort does not bind when capital markets are perfect because the principal can “sell the agent the firm,” that is, allow the agent to absorb all of the costs of the bad outcome.
period. During the period the agent exerts maintenance effort \( z \). This effort is not observed by others, nor can the agent credibly reveal his effort.

We model maintenance as affecting the probability of a negative shock to the value of the property occupied by the tenant (either a renter or an owner). The tenant has possession of \( H_t \) units of the housing stock at the end of period \( t \). Here \( H_t \) denotes the quantity of housing; it enters the felicity function, equation (1).

The agent’s maintenance effort \( z_t \) will determine the fate of the housing unit. As shown in figure 1, the house occupied by a tenant (whether an owner or a renter) undergoes either a good shock (in which case nothing happens) or a bad shock. Houses that suffer the bad shock lose a proportion \( \theta \) of their quantity; in other words, they shrink by an amount \( \theta \). This loss is realized at the beginning of the next period.

Young agents will want to borrow to finance the purchase a house. Unlike older agents, young agents are liquidity constrained. They have only their first-period endowment on hand, \( Y^1_0 \), to pledge as a downpayment. Beginning in the second period of life, agents who have not defaulted will have access to the expected present discounted value of their entire endowment stream. In essence, we assume that only young agents have a default option; thus, older agents can borrow at the risk-free rate.

Intermediation of funds and rental contracts take place through an economy-wide, zero-cost, zero-profit institution that completely spreads idiosyncratic risk. Damage to individual properties and defaults by individual borrowers will be spread amongst all landlords and savers.
Because of the linearity of preferences, an equilibrium with intermediation requires that the risk-free rate $R$ satisfy $R\beta = 1$. If $R\beta < 1$ all agents would prefer to bring consumption forward by borrowing; if $R\beta > 1$ all agents would prefer to perpetually defer consumption into the future by saving.

Because of the default option a young agent will not pay the risk-free rate on a mortgage. Denote the gross rate paid by an individual borrower $j$ as $\rho^j > R$; the difference between this rate and the risk-free rate is a credit spread.

In the same way, because some fraction of rental properties will sustain damage, individual renters will pay a rental rate $\bar{q}$ per unit housing while landlords will receive only $q$.

Homeowners who begin the second period of life with an outstanding mortgage can either repay the mortgage or default.\(^{11}\) The defaulter’s mortgage is wiped away immediately, but the defaulter is barred from the mortgage markets from then on.\(^{12}\) In practical terms, this means that homeowners who default on their mortgages are forced to rent after they have been evicted.

We model foreclosure law as the constant hazard $k$ of not being evicted from the property (and of the bank taking possession).\(^{13}\) Thus large values of $k$ correspond to longer foreclosure periods and more borrower-friendly foreclosure laws.

The homeowner’s decision problem is shown in figure 2.

We can thus divide agents in our economy into five groups:

\(^{11}\)In reality, homeowners have the opportunity to cure a delinquent mortgage; that is, to make up missed principal and interest payments following a period of delinquency. In our model households face no liquidity risk and hence will not want to take advantage of this feature.

\(^{12}\)This convention is used by Chatterjee, Corbae, Nakajima, and Ríos-Rull (2003) and others.

\(^{13}\)See section 3.1 for a discussion of real-world foreclosure law.
<table>
<thead>
<tr>
<th>Agent type</th>
<th>Value function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Young agents who borrow to finance a home</td>
<td>$V_0^j$</td>
</tr>
<tr>
<td>2. Agents with a mortgage who are considering default</td>
<td>$V_1^j$</td>
</tr>
<tr>
<td>3. Older agents with access to perfect capital markets</td>
<td>$V_j^j$</td>
</tr>
<tr>
<td>4. Agents in foreclosure</td>
<td>$W_j^j$</td>
</tr>
<tr>
<td>5. Renters</td>
<td>$\Omega_j^j$</td>
</tr>
</tbody>
</table>

The value functions are indexed by $j$ because agents differ in their endowments. Agents in foreclosure are those who have defaulted but have not yet been evicted from their property.

**Analysis**

We begin with a few simple results (derivations are in appendix A) about the policies and value function of the four types of agent. All of the discussion here will assume a set of restrictions on the model’s parameters that rule out degenerate or nonsensical equilibria. These restrictions are laid out in appendix A.4.

Because of the incentive problem, renters exert no effort and rental properties suffer the bad outcome with certainty. This raises the user cost of housing for renters above that for all other types. As a result, only those households who have defaulted in the past will rent. Facing such a high user cost, renters will have the lowest expected utility for the same wealth level of all agents in the model.

In general, agents will exert effort to maximize:

$$\max_z z^2/2\alpha + z\beta \{ \text{Value of good shock} \} + (1 - z)\beta \{ \text{Value of bad shock} \}.$$
At an interior optimum (when $0 < z < 1$), this implies an effort level of:

$$z = \alpha \beta \left( \text{Value of good shock} - \text{Value of bad shock} \right).$$

This holds true for young agents, owner-occupiers, agents in foreclosure and renters. For renters, of course, the one-period anonymous nature of the rental contract forces the agent’s value function to be the same under both the good and the bad shocks, hence the renter’s zero effort.

By contrast to renters, agents in foreclosure will exert some effort. While it might seem counterintuitive that agents in foreclosure would undertake costly maintenance effort, as long as foreclosure law allows them some chance of staying in the property (that is, $k > 0$) they will have some incentive to maintain the property. Agents in foreclosure may be ejected by the foreclosure process or they may voluntarily leave and choose to rent. If the original property has suffered several bad shocks in a row the agent may indeed find it preferable to rent a larger structure than to live in the remnants of his original property. Thus the value function $W^i(H)$ of an agent who enters foreclosure with a house of size $H$ will depend on foreclosure law $k$ and the value to renting $\Omega^i$. The closed-form solution to $W(H)$ is complex, see appendix A.3.3 for a complete discussion. However, a lower bound on the value function $W(H)$ can be formed by a weighted sum of
the value of being in a house of size $H$ forever and of renting:

$$W(H) \geq \underline{W}(H) \equiv \frac{1}{1 - k\beta} \log(H) + \beta \frac{1 - k}{1 - k\beta} \Omega^j$$

$$+ \left(1 + \log(1 - \theta)\right) \log(1 - \theta) \frac{k\beta}{1 - k\beta}.$$ 

The lower bound on $W, \underline{W}$, was constructed by assuming that the agent’s policy satisfied two conditions: (1) The agent exerts constant effort each period, and (2) The agent does not voluntarily quit the property. Neither one of these assumptions is strictly true, but both are plausible if renting is a particularly bad outcome and if the initial house size is large enough.

An agent who passes the second period of life without defaulting then has both a higher flow of endowments and access to perfect capital markets. Further assuming a steady state with constant prices ($P_{t+1} = P_t = P$), we can derive the optimal amount of housing consumed and effort expended. It turns out that these are given by:

$$PH^* = \frac{\sigma}{1 - \beta + \beta \theta (1 - z^*)}, \text{ and: }$$

$$z^* = \alpha \beta \theta PH^*.$$ 

The term in the denominator of equation (4) can be interpreted as the user cost of housing in our model. The user cost of housing typically has three elements: interest payments, depreciation, and capital gains. Here the discount factor $\beta$ captures the time cost of money, the term $(1 - z)\theta$ captures (endogenous) depreciation,
and, in the steady-state, capital gains collapse to zero.

Assuming that the agent began the second period of life with a housing stock $H_1$ and a mortgage $D$, and that he does not default, his value function is:

$$V^j_1(D, H_1)_{\text{Repay}} = \left[ Y^j - D + PH_1 - PH^* \right]$$

$$+ \frac{1}{1 - \beta} \left[ Y^j + \sigma \log(H^*) - \frac{z^*^2}{2\alpha} \right].$$

The homeowner has a one-time default option in the second period of life. If he defaults, the mortgage is discharged ($D = 0$) and the agent enters the foreclosure process. With probability $k$ he remains in the property for at least one period and his continuation utility is given by $W^j(H)$. With probability $1 - k$ the agent is immediately ejected and he becomes a renter, obtaining a continuation utility of $\Omega^j$:

$$V^j_1(H_1)_{\text{Default}} = Y^j + k \beta \mathbb{E} \{ W^j(H_1) | z \} + (1 - k) \beta \Omega^j.$$

At the beginning of the second period of life, the agent repays or defaults, giving the value function $V^j_1(D, H)$:

$$V^j_1(D, H) = \max_{\text{Repay, Default}} \left\{ V^j_1(D, H_1)_{\text{Default}}, V^j_1(D, H_1)_{\text{Repay}} \right\}.$$
A newly-born agent’s problem can thus be written:

\[
V_0^j = \max_{H_0, z_0} Y_0^j - x_0 + \sigma \log(H_0) - \frac{z_0^2}{2\alpha} \\
+ \beta \left\{ z_0 V_1^j (D, H_0) + (1 - z_0) V_1^j (D, (1 - \theta) H_0) \right\}
\]

The agent chooses a stock of housing, \(H_0\), implying a total cost of \(PH_0\) (again under the assumption of a steady state). This initial cost is financed in part by a downpayment, \(x_0\), with the remainder of the first period’s endowment, \(Y_0^j - x_0\), going to consumption. In addition, the agent takes out a loan to cover the remaining cost of the house: \(\ell = PH_0 - x_0\). In the second period of life the agent will owe an amount \(D = \rho^j \ell\). Because agents have access to perfect capital markets beginning in the second period of life, the agent can pay the mortgage off immediately.

**Default, Credit Rationing, and House Prices**

The maximization problem in the second period of life is over the repayment decision. If the agent defaults on the loan, his consumption may increase, but his long-run utility will be lower. More specifically:

<table>
<thead>
<tr>
<th>Decision</th>
<th>Consumption</th>
<th>Continuation Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repay</td>
<td>(Y^j - D + PH_1 - PH^*)</td>
<td>(V^j)</td>
</tr>
<tr>
<td>Default</td>
<td>(Y^j)</td>
<td>(W^j (H_1))</td>
</tr>
</tbody>
</table>
Note that because if the agent repays he gains access to perfect capital markets, it is possible for the term $Y^j - D + PH_1 - PH^*$ to be negative. Agents default if and only if the value of doing so exceeds the value of repaying. This is equivalent to the condition:

\begin{equation}
D + (H^* - H_1)P > \beta [V^j - W^j(H_1)].
\end{equation}

An immediate consequence of this formulation is that negative equity in the home is a necessary condition for default. That is, if:

$$D < PH_1,$$

the agent will not default. This in turn guarantees that a large enough downpayment will always be sufficient to prevent default in this model.

However, not all agents may be able to afford a large enough downpayment to guarantee repayment. Indeed, for sufficiently large values of $n$ it is certain that some agents will not be able to afford a large enough downpayment. (Recall that $n$ determines the growth in endowment from the first period of life, $Y^j_0$, to its permanent level, $Y^j = nY^j_0$.)

Furthermore, another consequence to the default condition, equation (10), is that agents default in the event of bad shock or not at all. To see this, notice that the bad shock means a lower value of $H_1$; in fact, if the agent suffers the bad shock then $H_1 = (1-\theta)H_0$. The left-hand-side of equation (10) increases linearly as $H_1$ decreases. The right-hand-side, by contrast, is concave in $H_1$, as seen in equation
If equation (3) holds for some $H_1 = h$ then it will hold for $H_1 = h' < h$.

Thus, we can concentrate on the marginal borrower, one who sets his downpayment equal to his entire period zero endowment, $Y_0^j$, and who will default in the event of the bad shock but will repay in the event of the good shock. From the borrower’s period 0 decision problem, equation (9), we know that effort will satisfy:

$$z_0 = \alpha \beta \left[V_1^j(D, H_0) - W^j((1 - \theta)H_0)\right],$$

substituting from (8) for $V_1^j$:

$$= \alpha \beta \left[PH_1 - D + \tilde{V}_1 - W^j((1 - \theta)H_0)\right],$$

where:

$$\tilde{V} \equiv -PH^* + \frac{1}{1 - \beta} \left[\sigma \log(H^*) - \frac{z^2}{2(\alpha)}\right],$$

thus:

$$z_0 = -\alpha \beta D + \alpha \beta \Delta. \tag{11}$$

Equation (11) gives the effort level, and hence the probability of repayment, conditional on loan terms (the face value of the loan, $D$). The term $\Delta$ at the end of equation (11) captures the difference between the continuation utilities of not defaulting and of defaulting. It is defined as:

$$\Delta \equiv \tilde{V}_1 + PH_1 - W^j((1 - \theta)H_0). \tag{12}$$

Note that this term does not depend on $D$.

The lender made a loan of size $\ell$ in period zero. The face value of the loan due in the next period, $D$, will be as low as possible without violating the zero-profit
constraint. Assuming that the bank recovers an amount $K$ in present value on loans that default, the zero-profit condition can be written:

\[
\mathbb{E} \{ \text{Profits} \} = (1 - z_0)K + z_0 D - R\ell \geq 0. \tag{13}
\]

From equation (11) we know that effort while young is a function of the loan terms. Substituting in we can rewrite the bank’s expected profit function as:

\[
\mathbb{E} \{ \text{Profits} \} = -\alpha_\beta \left[ D^2 - \Delta D + \frac{R\ell}{\alpha\beta} \right] \geq 0.
\]

(Here we have also assumed that $K = 0$ for simplicity.) This function is a downward-pointing parabola in $D$, as shown in figure 3. For a fixed loan size $\ell$, as the face value of the mortgage (and hence the credit spread), $D$, increases, expected profits initially increase and then decrease. The maximum expected profits occur when the face value of the loan is set to $\Delta/2$.

As shown in figure 4, as the loan size $\ell$ increases, the entire parabolic profit schedule of the lender shifts down. At a certain critical loan size the lender can no longer make non-negative profits at any credit spread. In this case, increasing the credit spread pushes down the incentive to work more than it increases revenue.

Foreclosure law will affect the number of credit rationed agents by affecting the penalty for default. As the period of rent-free living in a home following default increases, the difference between the good and bad outcomes decreases. Thus, the incentive to work hard and avoid the bad outcome decreases. In the model, this effect will emerge via $\Delta$. Note that the maximum revenue that can
be obtained by the lender is increasing in $\Delta$. We will show that $\Delta$ is in turn decreasing in the foreclosure law parameter $k$.

From equation (12) we see that $\Delta$ is, in essence, the difference between the continuation value function after repaying the loan, $V$, and the continuation value function after defaulting, $W$. That is, $\Delta$ is roughly $V - W$. From equation 3 we see that $W$ is, in turn, increasing in $k$. The longer one can expect to stay in a property following foreclosure, the less onerous foreclosure is.

Defaulter-friendly foreclosure laws make default less painful. This in turn lessens the incentive of the marginal borrower to maintain his property during the first period of life. Lenders must bid up their credit spreads on loans to young agents, further exacerbating the incentive problem.

Some young agents may have high enough endowments to make large down-payments, thus assuring lenders of repayment. These relatively rich agents will not be affected by foreclosure laws (or they will be affected only insofar as they are required to make larger downpayments while young).

Poorer agents, though, will be directly affected by foreclosure laws. Because they do not have enough cash on hand while young to make large downpayments, lenders are forced to charge them a credit spread. Defaulter-friendly foreclosure laws force these spreads up. Indeed, very poor agents will be credit rationed entirely; they will not be able to get a loan large enough to cover the cost of their ideal house at any interest rate. Note that, by assumption, all agents in the model can afford their ideal desired houses if they have access to perfect capital markets.
These poorer agents will, while young, be forced to buy smaller houses than desired at every price level. In effect, their demand curves have shifted in. Thus, the economy-wide aggregate demand curve will also shift in as foreclosure laws become more defaulter-friendly. (By assumption the stock of housing is fixed.) Thus the equilibrium price of housing will fall as foreclosure laws become more defaulter-friendly.

Note that the reaction of equilibrium house prices to foreclosure law depends heavily on the distribution of endowments among young agents. The credit rationing mechanism in this model is an absolute threshold of wealth; agents above the threshold are not affected in the least, while agents below the threshold are. The threshold is determined by foreclosure law and is not itself a function of the distribution of agents or of the price of housing. Thus, two economies with the same mean endowment may have very different price reactions in foreclosure law. The economy with more poor agents will see larger declines in prices than the economy with fewer poor agents.

3 Foreclosure Law and House Prices: Empirics

In order to test the effects of foreclosure law we need to compare outcomes under different foreclosure laws. In an ideal experiment states would periodically (and randomly) switch their foreclosure laws. In reality, states have not substantially altered the main provisions of their foreclosure laws since the Great Depression.

Given that foreclosure laws only vary across states and not over time, we ex-
ploit the *spatial* variation in foreclosure laws. However, spatial variation can also be problematic because foreclosure laws are not distributed randomly across the United States: neighboring states tend to have similar foreclosure law regimes. This pattern raises concerns because other factors that affect house prices vary across regions. For example, access to water, fertile soil, and other amenities shape employment opportunities and the desirability of certain locations. Without controls for these local factors, major layoffs in a geographically concentrated industry, for example, could be misconstrued as an effect of the laws.

We identify the effects of the laws, while still controlling for these regionally varying factors, by comparing census tracts along state borders. These nearby tracts share similar values for unobserved regional factors yet are subject to different foreclosure laws. This approach is conceptually similar to the regression discontinuity approach discussed in Hahn, Todd, and Van der Klaauw (2001).

To carry out this analysis, we construct two data sets. The units of analysis in both data sets are tracts from the 1990 Census. Census tracts are designed to be geographically cohesive; they rarely span neighborhood barriers such as train tracks. Although tracts are intended to include approximately 4,000 residents, in reality the number varies between 1,500 and 8,000.

The first dataset (the city sample) contains approximately 12,000 census tracts in 55 groups of contiguous metropolitan counties that span state lines. In 35 of these groups, all of the counties are part of the same metropolitan statistical area (MSA) as defined by the Census Bureau. In the other groups, the counties belong to two or more MSAs that border each other. Nonetheless, each county group
largely represents a cohesive housing market; because houses within a market are at least partially substitutes for each other, house prices within each group are likely to be affected similarly by neighborhood factors.

The second dataset (the national sample) includes all 58,000 census tracts in the United States.\textsuperscript{14} By including all counties in the United States, we mitigate any concerns that our selection of counties in the first data set are in any way not representative. In addition, although tracts away from the border do not help identify the effects of foreclosure laws, they help estimate other coefficients in the model with more precision.

\subsection{3.1 Foreclosure Law}

Our theory identifies foreclosure law with the single parameter $k$ that gives the probability of a defaulter remaining in his house each period. We have two empirical counterparts for $k$: first, an estimate of the actual number of days a defaulter can expect to stay in his house (the \textit{days} variable), and second, a set of indicator variables for features of foreclosure laws.\textsuperscript{15}

Although foreclosure laws are complex and somewhat difficult to code, three main features characterize every state’s law: (1) Whether the state requires the \textit{judicial foreclosure procedure}, (2) Whether the state permits a \textit{statutory right of redemption}, and (3) Whether the state forbids \textit{deficiency judgments}. The most

\textsuperscript{14}We drop census tracts with no residents or no owner-occupied housing units.

\textsuperscript{15}The \textit{days} measure is drawn from Freddie Mac’s guidelines as to the expected length of time of a foreclosure. See Jankowski (1999) pp. 2–11. According to these estimates, a foreclosure without any complications should take 53 days (the shortest) in Texas and 342 days (the longest) in Maine.
costly of these three measures, from the perspective of the lender, is the judicial foreclosure requirement. In states requiring this process, lenders must proceed through the court system in order to foreclose on a property; this requirement increases the cost of a foreclosure by approximately ten percent of the outstanding loan balance and increases its length, on average, by five months.\(^{16}\) In the other states lenders have the option of using a \textit{power-of-sale} procedure in which an independent trustee oversees the sale.

Turning to the other two features of foreclosure law, a statutory right of redemption allows the borrower to redeem the property for a period of time after the foreclosure sale; a deficiency judgment allows a lender to seize the borrower’s personal assets in order to satisfy any mortgage debt still outstanding after the foreclosure sale. These two remedies are rarely exercised by either the borrower or the lender.\(^{17}\) In examining the effect of foreclosure laws on loan size, Pence (2003a) found that a judicial foreclosure requirement had a larger and more robust effect than the other two foreclosure measures.

States that require judicial foreclosure processes also tend to have long foreclosure processes. Figure 5(a) shows the distribution of days in all states, while 5(b) shows the distribution separately for states requiring a judicial foreclosure

\(^{16}\)See Pence (2003b); Ciochetti (1997), Clauretie (1989), Clauretie and Herzog (1990), and Wood (1997) also document higher costs in judicial foreclosure states. Foreclosures can be ten months longer in judicial than in nonjudicial states.

\(^{17}\)In some states, the availability of a statutory right of redemption or deficiency judgment depends on whether a lender follows a judicial foreclosure process or a power-of-sale process. In these states, we assume that a lender follows a power-of-sale procedure if available, and so statutory rights of redemption and deficiency judgments are not permitted. For more background on foreclosure laws, see Capone (1996) or Schill (1991)
process and those not requiring it. Both sets of states are clustered in the northeastern United States, as shown in figures 6 and 7, although New Mexico, Louisiana, and South Carolina, among others, have lengthy judicial foreclosure proceedings. Figure 7 also shows the census tracts that make up the city sample (also listed in table 1). Of the 55 MSA groups in our city sample, 28 include at least one state that requires a judicial foreclosure process and one that does not.

### 3.2 Other covariates

As our measure of house prices we use the natural logarithm of the median house value in each census tract in our sample. We also control for characteristics of the census tract residents and housing stock that may affect housing prices. Specifically, we include controls for the age, education, and labor force participation status of the tract residents as well as controls for the percent of homes that are owner-occupied, rented, vacant, or mobile, the median age of the housing units in the tract, and the median rent charged. We also include the incidence of homicides and robberies as predicted by CAPIndex.\(^{18}\) Table 2 displays the means and standard deviations of these variables.

House prices may reflect other laws and policies than simply judicial foreclosure requirements. On the state level, we control for each state’s maximum income tax rate and for its personal and homestead consumer bankruptcy exemptions and its wage garnishment laws.\(^ {19}\)

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\(^{18}\)See www.capindex.com.

\(^{19}\)We follow Lehnert and Maki (2002) in coding state bankruptcy exemptions.
3.3 The Partial Linear Regression Model

We use a partial linear model to estimate the effects of foreclosure laws on house prices. The nonparametric component of this model is a smooth function of unknown form that takes on a different value at each census tract. This function soaks up all factors that vary with location: events such as plant closings, for example, or local disamenities such as landfills that have effects throughout a given metropolitan area or larger region. While the effect of a plant closing may be felt most keenly in a given neighborhood, the ripple effects are likely felt throughout the city. As long as these factors change smoothly over space, while the laws change discontinuously at the state border, both the laws and these unknown factors can be identified.

The partial linear model can be written as

\[
y = \alpha(\text{census tract}) + X\beta + \epsilon,
\]

where \(\alpha(\text{census tract})\) is a function that takes on a different value at each census tract. As in the standard linear model, this model assumes that \(\alpha\) and \(X\) are uncorrelated with \(\epsilon\).

We follow the method of Robinson (1988) in estimating this model. Note that after taking expectations of all variables \textit{conditional only on their location}, the
partial linear model can be rewritten as:

\begin{align}
(15) \quad y - E(y|\text{census tract}) &= \alpha(\text{census tract}) - E(\alpha|\text{census tract}) \\
&\quad + \left[ X - E(X|\text{census tract}) \right] \beta + \epsilon.
\end{align}

Notice that the $\alpha(\text{census tract})$ term now drops out of the equation because it varies only by location, hence $\alpha - E(\alpha|\text{census tract}) = 0$. $E(\epsilon|\epsilon)$ also drops out of the equation since by assumption it equals zero.

To estimate the model in this form, we first use Nadaraya-Watson regression to estimate the expected values of the dependent variable, $y$, and each of the explanatory variables, $X \equiv [x^1, \ldots, x^K]$, conditional only on their location. The expected value of each variable at a given tract is essentially a weighted average of its values at nearby tracts, with closer tracts receiving greater weight. Denote these expected values $\overline{y}, \overline{x^1}, \ldots, \overline{x^K}$:

\begin{align}
(16) \quad \overline{x^j} = \frac{\sum_{i=1}^{N} x^j_i K\left( d_{i,j} / h^j \right)}{\sum_{i=1}^{N} K\left( d_{i,j} / h^j \right)}, \quad \text{and:} \quad \overline{y} = \frac{\sum_{i=1}^{N} y_i K\left( d_{i,\ell} / h^y \right)}{\sum_{i=1}^{N} K\left( d_{i,\ell} / h^y \right)}, \quad \ell = 1, \ldots, N.
\end{align}

Here $d_{i,j}$ denotes the great circle distance between the centroids of census tracts $i$ and $j$, $K$ denotes the kernel and $h^j$ denotes the bandwidth used with the variable $x^j$. We used a variety of kernels (Gaussian, triangular, and Epanechnikov) and, as is normally the case, our results were not sensitive to the choice of kernel. As we discuss in more detail below, we used a cross validation procedure to choose an optimal bandwidth, $h$, separately for each variable.
For the second stage, define $\hat{y}$ and $\hat{X}$ to be residuals from the Nadaraya-Watson estimates from the first stage:

$$\hat{y} \equiv y - \overline{y} \text{ and } \hat{X} \equiv \begin{bmatrix} x^1 \ldots x^k \end{bmatrix}, \quad \hat{x}^j \equiv x^j - \overline{x}^j.$$

Equation (15) can now be written as:

$$\hat{y} = \hat{X} \beta + \epsilon.$$  

This equation can be computed using OLS, where the dependent variable and all regressors are residuals from Nadaraya-Watson estimates.

As an example, we will illustrate how the residuals are formed for the area comprising census tracts in the Fargo, North Dakota and Moorhead, Minnesota MSAs. Figure 8 shows the Nadaraya-Watson estimates of days near the Minnesota-North Dakota border (note that days is 89 in MN and 150 in ND). Because days varies only by state (not by census tract), and because we use a bandwidth of nine kilometers, we would expect the estimates to converge rapidly to their true values.\(^{20}\) However, for census tracts whose geographic center is within nine kilometers of the state border, the expected value of days is a weighted average of the values of days in both states. For census tracts farther from the border, the expected value equals the state’s value.\(^{21}\) Similarly, the residuals (shown in figure 9),

\(^{20}\)We discuss bandwidth selection later.

\(^{21}\)This description is literally true for the triangular and Epanechnikov kernels, which place zero weight on observations outside of the bandwidth. It is approximately true for the Gaussian kernel, which places weights on all observations; these weights are minuscule for tracts outside of the bandwidth.
which are the difference between the actual and expected values of days for each census tract, are positive for census tracts in North Dakota within 9 kilometers of the border and are negative for census tracts in Minnesota within 9 kilometers of the border. Residuals are zero for outlying tracts. Notice that the magnitude of the residuals is larger as one approaches the border (from either side).

The most important factor controlling the residuals is the bandwidth used in the Nadaraya-Watson estimation procedure. With a very small bandwidth, the Nadaraya-Watson estimate of state foreclosure laws will rapidly converge to the true state foreclosure law as one moves away from state borders. As proposed by Pagan and Ullah (1999) and others, we chose bandwidths for each variable by minimizing the squared expected prediction error (EPE). The prediction error for variable $j$ at a given observation $\ell$ under a trial bandwidth $h$, $e^j_{\ell}(h)$, is:

$$
e^j_{\ell}(h) = x^j_{\ell} - \tilde{x}^j_{\ell}, \text{ where:}
$$

$$
\tilde{x}^j_{\ell} = \frac{\sum_{i=1, i \neq \ell}^N x^j_{i} K\left(d_{i,\ell}/h\right)}{\sum_{i=1, i \neq \ell}^N K\left(d_{i,\ell}/h\right)}
$$

The EPE is then just the sum of squared prediction errors, $\sum_{\ell}[e^j_{\ell}(h)]^2$. Figure 10 shows the EPEs for the days measure and the log median home price.

From figure 10 we see that the EPE-minimizing bandwidth for variables that change sharply at state borders, such as the days measure, tends to be small. For variables that vary more smoothly with distance, such as house prices, the EPE-minimizing bandwidth tends to be larger.
3.4 Results

The coefficients and robust standard errors from OLS estimation of equation (17) are presented in table 3. Each combination of sample (city vs. national) and foreclosure law measure (days vs. indicator variables) is presented in a separate column.

From the first four rows of the table, we see that foreclosure laws, however measured, do have a statistically and economically significant negative effect on house prices. Defaulters living in states with the most defaulter-friendly foreclosure laws (that is, the top quartile of days) can expect to spend about 270 days in foreclosure before being evicted, while defaulters living in states with the least defaulter-friendly foreclosure laws (that is, the bottom quartile of days) can expect to spend about 70 days in foreclosure before being evicted. Multiplying the estimated coefficients on days by the 200-day difference between the most and least defaulter-friendly states gives us an effect of about 4.7 percent (the city sample) or about 2.6 percent (the national sample).

In the same way, we estimate that house prices in states requiring the judicial foreclosure procedure are about 3.8 percent lower (the city sample) or about 2.4 percent lower (the national sample) than house prices in other states. The other foreclosure laws we identified are generally associated with lower house prices, although their effects are much smaller and not statistically significant.

The estimated effect of foreclosure law decreases when we broaden the sample from selected cities to the continental U.S.; there are a couple of possible reasons for this decrease. First, as we have noted, the city sample offers the
cleanest comparison of foreclosure laws; the national sample may risk weighting some neighboring census tracts that are not in the same effective housing market. Second, the national sample includes some rural census tracts; in these regions lending standards could be influenced by the somewhat separate set of laws that govern farm foreclosures, which we have not attempted to control for.

4 Conclusion

Foreclosure laws govern the rights of tenant-borrowers and lenders from the about third or fourth month after the borrower last made a mortgage payment. Like consumer bankruptcy laws (which, broadly speaking, govern the rights of unsecured creditors and borrowers), foreclosure laws are largely determined by individual states. Unlike bankruptcy laws, though, states rarely alter their foreclosure laws. Most state foreclosure laws are legacies of the 1930s.

Although it might seem obvious that more generous foreclosure laws would hold house prices down, in fact, in most models, it is far from clear. We developed a formal model that incorporated foreclosure law into a typical principal-agent framework with moral hazard. We modelled foreclosure law as a parameter governing the expected length of time that a tenant-borrower could expect to remain in the house, rent-free, before being evicted. More generous foreclosure laws then impose a downpayment constraint on borrowers; if some borrowers are too poor to make the required downpayment on their desired house, they must settle for a smaller house. This has the effect of shifting in the demand curve for housing,
decreasing equilibrium house prices. Further, the size of the effect depends on the proportion of low-income households relative to high-income households. If the wealth distribution is skewed to the left (so that there are relatively more poor agents), the decrease in prices for a given level of foreclosure law generosity is larger.

We tested the implications of our model using the natural experiment afforded by spatial variation in state laws. On one side of a state border, foreclosure laws are more generous than on the other. However, many of the unobserved characteristics that affect house prices are probably quite similar near the border. We controlled for these unobserved characteristics by allowing the similarity of the unobserved components of two houses to vary non-parametrically depending on the distance between them.

The most important state-varying component of foreclosure law is whether a state requires court supervision of a foreclosure through a judicial foreclosure process. This process is substantially more costly and time consuming to the lender than the power-of-sale alternative. We find that the presence of this type of law is associated with a decrease of house prices by between 2.8 and 3.8 percent.

Using the expected duration of the foreclosure process (that is, the number of days before eviction), we found that every 100 day increase in duration was associated with between a 1.3 and a 2.4 percent decrease in house prices. States in the longest quartile have foreclosure proceedings that last about 270 days, which is 200 days longer than states in the fastest quartile. Thus states with the most defaulter-friendly foreclosure laws will have house prices that are between 2.6 and
4.8 percent lower than states with the least defaulter-friendly foreclosure laws.

References


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Figure 1: Maintenance Effort and Housing Stock

House = $H_t$; Exert effort $z_t$

Good shock $\rightarrow H_{t+1} = H_t$

Prob. = $z_t$

Bad shock $\rightarrow H_{t+1} = (1 - \theta)H_t$

Prob. = $1 - z_t$
Figure 2: Foreclosure Law and the Decision Problem of Owner-Occupiers

NOTE. Figure shows how the decision problem for a typical owner-occupier is affected by foreclosure law. Beginning from the left-most node, the owner realizes the housing shock and inherits a stock $H_0$ from the previous period. The owner must then decide whether to pay the mortgage or default; if he pays the mortgage he realizes another housing shock and returns to the first node. If he defaults he enters foreclosure. He remains in the property each period with probability $k$; with probability $1 - k$ he is evicted and must rent housing from then forward.
Figure 3: Lender’s Expected Profits as a Function of Credit Spread

\[ \alpha \beta \Delta/4 - RL \]

\( D^* \)

Figure 4: The Effect of Increasing Loan Size (Decreasing Downpayment)

\( L=4 \)

\( L=7 \)

\( L=10 \)
Figure 5: Distribution of Days to Eviction

(a) All States

(b) By Judicial Foreclosure Procedure Requirement
Figure 6: Days to Eviction by State

- 53 ≤ Days ≤ 100
- 101 ≤ Days ≤ 146
- 150 ≤ Days ≤ 189
- 200 ≤ Days ≤ 342
Figure 7: Foreclosure Laws and MSA Census Tracts

- Requires judicial foreclosure
- Does not require judicial foreclosure
NOTE. Figure shows the Nadaraya-Watson estimates of the number of days to eviction by location in the urban area comprising Fargo, ND and Moorhead, MN (indicated by the red box in the inset map). Centroids of census tracts are marked with an “x.” The value of days is 150 in North Dakota and 89 in Minnesota.
Figure 9: Residuals from Nadaraya-Watson Estimates of days

NOTE. Figure shows residuals from the Nadaraya-Watson estimates of days by location in Fargo/Moorhead. The estimated value is greater than the true value in those areas with negative residuals.
NOTE. Graph shows the expected prediction errors, as defined in equation (18), for the number of days to eviction in a foreclosure (the days measure) and the log median census tract home price. Prediction errors are normalized so that their minima equal one.
Table 1: List of MSAs in City Dataset

**MSA Pair** List of counties

<table>
<thead>
<tr>
<th>MSA Pair</th>
<th>List of counties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile AL-Pensacola FL</td>
<td>Baldwin C., AL; Escambia C., FL</td>
</tr>
<tr>
<td>Mobile AL-Pascagoula MS</td>
<td>Jackson C., MS; Mobile C., AL</td>
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<td>New Orleans LA-Gulfport MS</td>
<td>Hancock C., MS; St. Tammany Parish, LA</td>
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<tr>
<td>Columbus GA-AL*</td>
<td>Muscogee C., GA; Russell C., AL</td>
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<td>Memphis TN-AR-MS*</td>
<td>Crittenden C., AR; DeSoto C., MS; Shelby C., TN; Tipton C., TN</td>
</tr>
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<td>Texarkana TX-Texarkana AR*</td>
<td>Bowie C., TX; Miller C., AR</td>
</tr>
<tr>
<td>Fort Smith AR-OK*</td>
<td>Crawford C., AR; Sebastian C., AR; Sequoyah C., OK</td>
</tr>
<tr>
<td>Reno NV</td>
<td>Placer C., CA; Washoe C., NV</td>
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<td>Cheyenne WY-Fort Collins CO</td>
<td>Laramie C., WY; Larimer C., CO; Weld C., CO</td>
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<td>Catoosa C., GA; Hamilton C., TN; Walker C., GA</td>
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<td>Minneapolis-St. Paul MN-WP</td>
<td>Dakota C., MN; St. Croix C., WI; Washington C., MN</td>
</tr>
<tr>
<td>Augusta-Aiken GA-SC*</td>
<td>Aiken C., SC; Columbia C., GA; Richmond C., GA</td>
</tr>
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<td>St. Louis MO-IL*</td>
<td>Jefferson C., MO; Madison C., IL; St. Charles C., MO; St. Clair C., IL; St. Louis C., MO; St. Louis City, MO</td>
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<td>Boone C., IL; Rock C., WI; Winnebago C., IL</td>
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<td>Dona Ana C., NM; El Paso C., TX</td>
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Wilmington NC-Myrtle Beach SC  Brunswick C., NC; Horry C., SC
Charlotte-Gastonia-Rock Hill NC-SC*  Gaston C., NC; Mecklenburg C., NC; York C., SC
Johnson City-Kingsport-Bristol TN*  Hawkins C., TN; Sullivan C., TN; Washington C., VA
Erie PA-Cleveland OH  Ashtabula C., OH; Chautauqua C., NY; Erie C., PA
Wheeling WV-OH*  Belmont OH; Marshall WV; OH C., WV
Pittsburgh PA-Steubenville OH  Beaver C., PA; Hancock C., WV; Jefferson C., OH;
Washington C., PA
Youngstown-Warren OH Sharon PA  Mahoning C., OH; Mercer C., PA; Trumbull C., OH
Parksburg-Marietta WV-OH*  Washington C., OH; Wood C., WV
Chicago-Gary IL-IN*  Cook C., IL; Kankakee C., IL; Lake C., IN; Will C., IL
Baltimore, MD-York / Lancaster, PA  Baltimore C., MD; Carroll C., MD; Harford C., MD;
Lancaster C., PA; York C., PA
Hartford, CT-Springfield MA  Hampden C., MA; Hartford C., CT; Tolland C., CT
Poughkeepsie, NY-Danbury, CT*  Dutchess C., NY; Fairfield C., CT; Putnam C., NY
Lawrence, MA*  Essex C., MA; Rockingham C., NH
Lowell-Fitchburg MA Nashua NH*  Hillsborough C., NH; Middlesex C., MA;
Worcester C., MA
Providence RI, Attleboro-Worcester MA  Bristol C., MA; Bristol C., RI; Hampden C., MA;
Norfolk C., MA; Providence C., RI; Windham C., CT; Worcester C., MA
New London, CT*  New London C., CT; Washington C., RI
Philadelphia-Wilmington-Atlantic City*  Burlington C., NJ; Camden C., NJ; Cecil C., MD;
Chester C., PA; Delaware C., PA; Gloucester C., NJ; New Castle C., DE;
Philadelphia C., PA
Portland-Salem OR-WA*  Clark C., WA; Multnomah C., OR
Portsmouth-Rochester NH*  Rockingham C., NH; Strafford C., NH; York C., ME
New York City*  Bergen C., NJ; Bronx C., NY; Fairfield C., CT; Hudson C., NJ;
Middlesex C., NJ; New York C., NY; Passaic C., NJ; Richmond C., NY;
Rockland C., NY; Union C., NJ; Westchester C., NY
Sussex, NJ-Port Jervis NY*  Orange C., NY; Sussex C., NJ
Trenton-Hunterdon NJ, Philadelphia  Bucks C., PA; Hunterdon C., NJ; Mercer C., NJ
Easton, PA-WA, NJ  Northampton C., PA; Warren C., NJ
Washington, DC*  Arlington C., VA; District of Columbia; Fairfax C., VA;
Frederick C., MD; Loudoun C., VA; Montgomery C., MD; Prince
George’s C., MD
Duluth-Superior MN-WI*  Douglas C., WI; St. Louis C., MN

NOTE. Table gives the MSA pairs and associated counties for the 55 cities in the city database. ∗: Indicates that all counties within county group belong to the same MSA as defined by the Census Bureau.
Table 2: Sample Moments of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>B-wdth (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log median house price</td>
<td>11.505</td>
<td>0.649</td>
<td>71</td>
</tr>
</tbody>
</table>

**Foreclosure Law Measures**

| Days to eviction (days)                      | 190.317| 93.530 | 9           |
| Judicial foreclosure procedure required      | 0.640  | 0.480   | 5           |
| Statutory right of redemption                 | 0.060  | 0.237   | 9           |
| Deficiency judgements prohibited             | 0.043  | 0.203   | 9           |

**Other State Laws**

| Max. state wage tax rate                     | 4.301  | 2.376   | 7           |
| Log homestead exemption                      | 8.332  | 2.702   | 11          |
| Log personal exemption                       | 8.842  | 0.531   | 71          |
| Garnishment                                  | 0.179  | 0.092   | 11          |

**Census Tract Characteristics**

| Log per-capita personal income               | 9.675  | 0.414   | 71          |
| Unemployment rate (percent)                  | 5.640  | 3.991   | 5           |
| Poverty rate (percent)                       | 8.442  | 8.903   | 3           |
| Log homicide score                           | 4.1278 | 0.780   | 13          |
| Log robbery score                            | 3.1414 | 1.244   | 7           |
### Housing Unit Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>1961</th>
<th>13.207</th>
<th>71</th>
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<tbody>
<tr>
<td>Median rent</td>
<td>544</td>
<td>195</td>
<td>5</td>
</tr>
<tr>
<td>Median year built</td>
<td>1961</td>
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</table>

#### Percent of housing stock that is:

<table>
<thead>
<tr>
<th>Housing Type</th>
<th>3.5812</th>
<th>8.140</th>
<th>9</th>
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</thead>
<tbody>
<tr>
<td>Manufactured housing</td>
<td>6.0111</td>
<td>5.590</td>
<td>9</td>
</tr>
<tr>
<td>Vacant units</td>
<td>26.2353</td>
<td>16.467</td>
<td>3</td>
</tr>
<tr>
<td>Rental units</td>
<td>67.8664</td>
<td>14.389</td>
<td>11</td>
</tr>
<tr>
<td>Two or three rooms</td>
<td>20.1847</td>
<td>14.610</td>
<td>3</td>
</tr>
<tr>
<td>Four or five rooms</td>
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### Demographics

#### Percent of population that are:

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<tr>
<th>Age Group</th>
<th>5.274</th>
<th>2.984</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young adult</td>
<td>12.389</td>
<td>4.064</td>
<td>7</td>
</tr>
<tr>
<td>Twenties</td>
<td>17.257</td>
<td>3.355</td>
<td>19</td>
</tr>
<tr>
<td>Thirties</td>
<td>13.637</td>
<td>3.270</td>
<td>11</td>
</tr>
<tr>
<td>Fourties</td>
<td>9.5023</td>
<td>2.492</td>
<td>19</td>
</tr>
<tr>
<td>Fifties</td>
<td>8.8804</td>
<td>3.310</td>
<td>9</td>
</tr>
<tr>
<td>Sixties</td>
<td>8.4398</td>
<td>4.687</td>
<td>7</td>
</tr>
<tr>
<td>Older</td>
<td>10.7587</td>
<td>22.430</td>
<td>1</td>
</tr>
<tr>
<td>Black</td>
<td></td>
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<td></td>
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</table>

#### Percent of population with:

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<tr>
<th>Education Level</th>
<th>30.5068</th>
<th>9.299</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>A high school degree</td>
<td>24.1304</td>
<td>6.174</td>
<td>9</td>
</tr>
<tr>
<td>Some college</td>
<td>15.1748</td>
<td>9.185</td>
<td>3</td>
</tr>
<tr>
<td>A four-year college degree</td>
<td>8.9949</td>
<td>8.165</td>
<td>1</td>
</tr>
<tr>
<td>A graduate degree</td>
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<td></td>
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</table>

#### Percent of population that:

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<tr>
<th>Move Status</th>
<th>11.1540</th>
<th>5.921</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moved in 1970–1979</td>
<td>13.7921</td>
<td>3.752</td>
<td>31</td>
</tr>
<tr>
<td>Moved in 1980–1984</td>
<td></td>
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<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Moved in 1989–1990</td>
<td>7.701</td>
<td>7.774</td>
<td>9</td>
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</tbody>
</table>

### Sample Statistics

<table>
<thead>
<tr>
<th>Sample Statistics</th>
<th>Count</th>
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</thead>
<tbody>
<tr>
<td>Owner-occupied housing units (weight variable)</td>
<td>1,004</td>
</tr>
<tr>
<td>Number of census tracts</td>
<td>12,135</td>
</tr>
</tbody>
</table>

**NOTE.** Table gives the means and standard deviations of the indicated variables by census tract, weighted by the number of owner-occupied housing units in each census tract.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample</th>
<th>National</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected number of days to eviction (days)</td>
<td>−0.000235***</td>
<td>−0.000128**</td>
</tr>
<tr>
<td></td>
<td>(0.000093)</td>
<td>(0.000066)</td>
</tr>
<tr>
<td>Judicial foreclosure procedure required</td>
<td>−0.038152**</td>
<td>−0.023772**</td>
</tr>
<tr>
<td></td>
<td>(0.016699)</td>
<td>(0.011803)</td>
</tr>
<tr>
<td>Statutory right of redemption required</td>
<td>−0.014041</td>
<td>−0.016407</td>
</tr>
<tr>
<td></td>
<td>(0.024269)</td>
<td>(0.019271)</td>
</tr>
<tr>
<td>Deficiency judgements prohibited</td>
<td>−0.008012</td>
<td>0.004774</td>
</tr>
<tr>
<td></td>
<td>(0.027160)</td>
<td>(0.024533)</td>
</tr>
</tbody>
</table>

**Other State Laws**

<table>
<thead>
<tr>
<th></th>
<th>Sample</th>
<th>National</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. state wage tax rate</td>
<td>0.000600</td>
<td>0.001022</td>
</tr>
<tr>
<td></td>
<td>(0.002774)</td>
<td>(0.002604)</td>
</tr>
<tr>
<td>Log homestead exemption</td>
<td>0.010821***</td>
<td>0.009951***</td>
</tr>
<tr>
<td></td>
<td>(0.002566)</td>
<td>(0.002911)</td>
</tr>
<tr>
<td>Log personal exemption</td>
<td>−0.01332</td>
<td>−0.00819</td>
</tr>
<tr>
<td></td>
<td>(0.00977)</td>
<td>(0.01132)</td>
</tr>
</tbody>
</table>
### Table 3 (continued from previous page)

**Wage garnishment**

<table>
<thead>
<tr>
<th></th>
<th>0.319279***</th>
<th>0.385020***</th>
<th>0.277507***</th>
<th>0.302383***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.112923)</td>
<td>(0.112522)</td>
<td>(0.076684)</td>
<td>(0.073669)</td>
</tr>
</tbody>
</table>

**Census Tract Characteristics**

**Log per-capita personal income**

<table>
<thead>
<tr>
<th></th>
<th>0.823489***</th>
<th>0.823419***</th>
<th>0.860319***</th>
<th>0.860350***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.013333)</td>
<td>(0.013332)</td>
<td>(0.006262)</td>
<td>(0.006261)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unemployment rate</th>
<th>-0.006264***</th>
<th>-0.006268***</th>
<th>-0.002054***</th>
<th>-0.002049***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.000839)</td>
<td>(0.000841)</td>
<td>(0.000412)</td>
<td>(0.000412)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Poverty rate</th>
<th>0.002327***</th>
<th>0.002304***</th>
<th>-0.000781***</th>
<th>-0.000779***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.000431)</td>
<td>(0.000433)</td>
<td>(0.000183)</td>
<td>(0.000183)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Log homicide score</th>
<th>-0.016000***</th>
<th>-0.015971***</th>
<th>-0.019512***</th>
<th>-0.019512***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.005228)</td>
<td>(0.005229)</td>
<td>(0.002852)</td>
<td>(0.002852)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Log robbery score</th>
<th>-0.001587</th>
<th>-0.001708</th>
<th>0.008973</th>
<th>0.008954</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.004629)</td>
<td>(0.004620)</td>
<td>(0.002256)</td>
<td>(0.002255)</td>
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</table>

**Housing Unit Characteristics**

**Median rent**

<table>
<thead>
<tr>
<th></th>
<th>-0.000119***</th>
<th>-0.000119***</th>
<th>-0.000102***</th>
<th>-0.000102***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.000018)</td>
<td>(0.000018)</td>
<td>(0.000012)</td>
<td>(0.000012)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Median year built</th>
<th>0.005005***</th>
<th>0.004999***</th>
<th>0.006645***</th>
<th>0.006647***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.000234)</td>
<td>(0.000233)</td>
<td>(0.000119)</td>
<td>(0.000119)</td>
</tr>
</tbody>
</table>

*continued on next page...*
Table 3 (continued from previous page)

Manufactured (percent of units)

<table>
<thead>
<tr>
<th></th>
<th>BC</th>
<th>BM</th>
<th>BC</th>
<th>BC</th>
<th>BF</th>
<th>BG</th>
<th>BJ</th>
<th>BE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.003472**</td>
<td>0.003473***</td>
<td>0.001970***</td>
<td>0.001970***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.000324)</td>
<td>(0.000324)</td>
<td>(0.000126)</td>
<td>(0.000126)</td>
<td></td>
<td></td>
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Vacant (percent of units)

<table>
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<tr>
<th></th>
<th>BC</th>
<th>BM</th>
<th>BC</th>
<th>BC</th>
<th>BF</th>
<th>BG</th>
<th>BJ</th>
<th>BE</th>
</tr>
</thead>
<tbody>
<tr>
<td>−0.002078***</td>
<td>−0.002111***</td>
<td>−0.000173</td>
<td>−0.000176</td>
<td></td>
<td></td>
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<tr>
<td>(0.000606)</td>
<td>(0.000604)</td>
<td>(0.000177)</td>
<td>(0.000177)</td>
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</table>

Rentals (percent of units)

<table>
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<tr>
<th></th>
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<th>BC</th>
<th>BC</th>
<th>BF</th>
<th>BG</th>
<th>BJ</th>
<th>BE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.002686***</td>
<td>0.002684***</td>
<td>0.001641***</td>
<td>0.001642***</td>
<td></td>
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<tr>
<td>(0.000246)</td>
<td>(0.000246)</td>
<td>(0.000142)</td>
<td>(0.000142)</td>
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Two or three rooms (percent of units)

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<th>BM</th>
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<th>BF</th>
<th>BG</th>
<th>BJ</th>
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<tbody>
<tr>
<td>−0.001949***</td>
<td>−0.001961***</td>
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<td>−0.002091***</td>
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<tr>
<td>(0.000328)</td>
<td>(0.000328)</td>
<td>(0.000169)</td>
<td>(0.000169)</td>
<td></td>
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Four or five rooms (percent of units)

<table>
<thead>
<tr>
<th></th>
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<th>BG</th>
<th>BJ</th>
<th>BE</th>
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<tbody>
<tr>
<td>0.003272***</td>
<td>0.003259***</td>
<td>0.001312***</td>
<td>0.001309***</td>
<td></td>
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<tr>
<td>(0.000399)</td>
<td>(0.000398)</td>
<td>(0.000194)</td>
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Demographics

Young adult

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<tbody>
<tr>
<td>0.009334***</td>
<td>0.009310***</td>
<td>0.007733***</td>
<td>0.007728***</td>
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<td></td>
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<tr>
<td>(0.000779)</td>
<td>(0.000780)</td>
<td>(0.000363)</td>
<td>(0.000363)</td>
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Twenties

<table>
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<th>BG</th>
<th>BJ</th>
<th>BE</th>
</tr>
</thead>
<tbody>
<tr>
<td>−0.005074***</td>
<td>−0.005106***</td>
<td>−0.007574***</td>
<td>−0.007579***</td>
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<td>(0.000898)</td>
<td>(0.000417)</td>
<td>(0.000417)</td>
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Thirties

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<th>BC</th>
<th>BC</th>
<th>BF</th>
<th>BG</th>
<th>BJ</th>
<th>BE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000804</td>
<td>0.000775</td>
<td>−0.002708***</td>
<td>−0.002713***</td>
<td></td>
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<tr>
<td>(0.001125)</td>
<td>(0.001125)</td>
<td>(0.000556)</td>
<td>(0.000555)</td>
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Fourties

<table>
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<th>BM</th>
<th>BC</th>
<th>BC</th>
<th>BF</th>
<th>BG</th>
<th>BJ</th>
<th>BE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.003558***</td>
<td>0.003530***</td>
<td>−0.001158**</td>
<td>−0.001164**</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(0.001221)</td>
<td>(0.001218)</td>
<td>(0.000575)</td>
<td>(0.000575)</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Table 3 (continued from previous page)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fifties</strong></td>
<td><strong>Sixties</strong></td>
</tr>
<tr>
<td>( -0.002531^{**} )</td>
<td>( -0.003080^{***} )</td>
</tr>
<tr>
<td>( (0.001204) )</td>
<td>( (0.000968) )</td>
</tr>
<tr>
<td>( -0.002558^{**} )</td>
<td>( -0.003112^{***} )</td>
</tr>
<tr>
<td>( (0.001204) )</td>
<td>( (0.000965) )</td>
</tr>
<tr>
<td>( -0.005105^{***} )</td>
<td>( -0.002567^{***} )</td>
</tr>
<tr>
<td>( (0.000594) )</td>
<td>( (0.000629) )</td>
</tr>
<tr>
<td>( -0.005110^{***} )</td>
<td>( -0.002574^{***} )</td>
</tr>
<tr>
<td>( (0.000594) )</td>
<td>( (0.000629) )</td>
</tr>
<tr>
<td><strong>Older</strong></td>
<td><strong>Black</strong></td>
</tr>
<tr>
<td>( -0.002067^{***} )</td>
<td>( -0.000682^{***} )</td>
</tr>
<tr>
<td>( (0.000770) )</td>
<td>( (0.000171) )</td>
</tr>
<tr>
<td>( -0.002107^{***} )</td>
<td>( -0.000678^{***} )</td>
</tr>
<tr>
<td>( (0.000768) )</td>
<td>( (0.000171) )</td>
</tr>
<tr>
<td>( -0.005979^{***} )</td>
<td>( -0.000477^{***} )</td>
</tr>
<tr>
<td>( (0.000602) )</td>
<td>( (0.000063) )</td>
</tr>
<tr>
<td>( -0.005986^{***} )</td>
<td>( -0.000477^{***} )</td>
</tr>
<tr>
<td>( (0.000602) )</td>
<td>( (0.000063) )</td>
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*continued on next page...*
Table 3 (continued from previous page)

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<th>Coefficient</th>
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<th>Standard Error</th>
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Regression Statistics

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<tr>
<td></td>
<td>57,888</td>
<td>57,888</td>
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</tr>
<tr>
<td></td>
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**Note.** Table gives results from estimating the partial-linear model described in section 3.3. The dependent variable is the log median house price in each census tract. Robust standard errors are in parentheses. Observations are weighted by the number of owner-occupied housing units in each census tract. **\( ***//**/\): Coefficient is significantly different from zero at the 1/5/10 percent confidence level.
A Model

A.1 Preferences, Endowments, Intermediation, and Information

A.1.1 Preferences and Endowments

Agents have one-period felicity functions over housing consumption, \( h \), non-housing consumption, \( c \), and maintenance effort \( z \) given by:

\[
 u(c, h, z) = \sigma \log(h) + c - \frac{1}{2\alpha}z^2; \quad c \geq 0, \quad h > 0, \quad 0 \leq z \leq 1.
\]  

(A.1)

With log-linear preferences, agents will choose to spend a constant amount (price times quantity) on housing (where possible). Agents live for multiple periods and have an effective discount factor given by \( \frac{1}{BC} \) where \( AH \) is their pure patience and \( AL \) their one-period survival probability and \( BC \) and \( BO \). We will write the effective discount rate as \( AC \), so that \( BC \). Thus agents value sequences of consumption, housing, and effort as:

\[
 \mathcal{U} \left( \{c_t, h_t, z_t\}_{t=0}^{\infty} \right) = \sum_{t=0}^{\infty} \beta_t \left[ \log(h_t) + c_t + z_t^2(2\alpha)^{-1} \right].
\]

Agents will be born at a rate just sufficient to replace agents who die. The housing endowments of agents that perish are divided equally among the newly-born agents. (In other words, our model features a perfect death tax.)

Agent \( j \) is born with an initial non-housing endowment of \( CY \), with a known, constant distribution function \( CH \). Endowments lie in the closed interval:

\[
 Y^j \in [Y, Y], \quad F(Y) = 0, \quad F(Y) = 1.
\]

An agent of type \( j \) receives the endowment \( Y^j_0 \) in the first period of life (while “young”) and then an endowment \( Y^j = nY^j_0 \) each period of life thereafter (while “adult”) with certainty. The parameter \( n \) is the growth in permanent income between youth and adulthood.

A.1.2 Maintenance Effort and Moral Hazard

At the beginning of a period an agent decides how much housing to occupy. He will occupy this housing “overnight” into the next period. During the period the agent exerts maintenance effort \( z \). This effort is not observed by others, nor can the agent credibly reveal his effort. This effort can be thought of as direct maintenance of the property; keeping a house in good condition requires continuous vigilance and a myriad of small
repairs. In addition effort may be thought of more broadly; for example, homeowners may be more engaged in local government decisions, may pay more attention to, and vote on, initiatives that affect school quality and other neighborhood attributes. Several studies have concluded that homeownership has external social benefits; in part, these benefits may be the result of homeowners expending more effort on maintaining the social fabric of their local community.22

We model maintenance as affecting the probability of a negative shock to the value of the property occupied by the tenant (either a renter or an owner). The tenant has possession of \( H_t \) units of the housing stock at the end of period \( t \). Here \( H_t \) denotes the quantity of housing; it enters the felicity function, equation (A.1).

The agent’s maintenance effort \( z_t \) will determine the fate of the housing unit. As shown in figure A.1, the house occupied by a tenant (whether an owner or a renter) undergoes either a good shock (in which case nothing happens) or a bad shock. Houses that suffer the bad shock lose a proportion \( \theta \) of their quantity; in other words, they shrink by an amount \( \theta \).

Maintenance effort \( z_t \) directly affects the probability of the good shock; in fact, for notational convenience, \( z_t \) is the probability of the good shock. (This is why effort \( z_t \) is constrained to be in the interval \([0, 1]\); it must be a valid probability.)

---

22 The literature on the social benefits of homeownership is vast; see Haurin, Parcel, and Haurin (2002) for a representative study and Dietz, Haurin, and Weinberg (2003) for a survey.
A.1.3 Intermediation

Young or poor agents (that is, those agents with low endowments) will want to borrow to finance their purchase of a house. In addition, high-income agents may want save or to invest in residential housing as an asset: they will own their own homes outright and, in addition, own other properties that are available for rent. Both of these types of intermediation (lending and renting) are assumed to occur anonymously; lenders will put funds on deposit with an economy-wide mutual fund and earn the average rate of return on all loans. Landlords will put their property into a similar economy-wide institution, and earn the rental rate less the average amount of damage incurred to their properties. In both rental and lending markets, landlords and lenders will earn an average rate of return with certainty because of our assumption that agents are distributed continuously. Individual renters and borrowers may damage their properties or default on their mortgages, but, averaging across the infinite number of these agents, there will be no aggregate uncertainty.

For a particular agent, denote by $h$ the amount of housing consumed and $H$ the amount of housing owned. Homeowners may also have a mortgage with a face value of $D$. However, in any given period, agents can consume more or less housing than $H$. Renters, for example, will own no housing, $H = 0, D = 0$, but will consume some housing, $h > 0$. Very wealthy individuals may own lots of houses but consume less than their total stock of housing, $H > h > 0$. In addition, wealthy individuals will also have positive net assets, denoted $A$. Owner-occupiers (the majority of households in the U.S. economy) will own and consume precisely the same amount of housing, $h = H > 0$.

In any period, we denote the sale price of a unit of housing as $P$. The rental rate on a unit of housing paid by renters is denoted $\bar{q}$, while the rental income on the same unit of housing received by landlords is denoted $q$. Because of the incentive problems inherent in renting, $q \leq \bar{q}$.

In the same way, the risk-free rate on savings is denoted $\bar{R}$. (The quantity of saving is denoted $A$.) Because utility is linear in consumption, as long as the risk-free rate satisfies $R \beta > 1$, households will be indifferent in which period they ultimately consume their endowment stream. If $R \beta < 1$ all agents will want to borrow to bring forward their endowments to consume now and no agents will want to lend. If $R \beta > 1$, all agents will want to save and put off consuming their endowments. Neither case can be an equilibrium, so we will take $\bar{R} = 1/\beta$.

Young agents (those newly-born) will borrow from a zero-profit economy-wide institution that acts as a principal. This lender makes an initial loan of $\ell$ and then demands a debt payment of $D = \rho^j \ell$. As we discuss later, the interest rate $\rho^j$ will depend on the amount of the downpayment made by my agent $j$. For the lender to make non-negative profits, it must be the case that:

(A.2) $\mathbb{E} \{\text{Payments by agent } j - R\ell\} \geq 0$.
Agents will have exactly one opportunity to default on any debts that they owe, at the beginning of the second period of life. Those agents who choose not to default then face perfectly-functioning capital markets and can borrow and lend freely at the risk-free rate. To summarize, at the beginning of period \( t \) there will be five types of agent in the economy:

1. Newly-born agents wishing to purchase a house.
2. Agents at the beginning of the second period of life who may default on their loans.
3. Owner-occupiers (agents in at least the third period of life who have not defaulted on any loans) who have access to perfect capital markets.
4. Homeowners in foreclosure; that is, agents who defaulted on their loan but have not yet been evicted. These agents will continue to occupy the house that they formerly owned, but they cannot sell the house. (We describe this process in greater detail in section A.2.)
5. Renters, who have no ownership rights to housing but who sign one-period anonymous rental contracts, so that \( H_t = 0, h_t > 0 \).

The budget constraints faced by each of these four types can be found in section A.5.

### A.2 Modelling Foreclosure Law

Homeowners begin the second period of life with an outstanding mortgage \( D \). Because they have access to the present discounted value of their expected lifetime earnings if they do not default, their choice is between paying off the mortgage completely or defaulting. If the homeowner defaults, the lender then attempts to repossess the property through the foreclosure process.

If the homeowner choose to default, his debt goes to zero immediately \( (D = 0) \) and he is excluded from the capital markets. In practical terms, this means that homeowners who default on their mortgages are forced to rent after they have been evicted.

Homeowners that default are then placed in the foreclosure process. We model foreclosure as the constant hazard \( k \) of not being evicted from the property (and of the bank taking possession). Thus large values of \( k \) correspond to longer foreclosure periods and more borrower-friendly foreclosure laws. The homeowner’s decision problem is shown in figure A.2.

### A.3 Value Functions

Each of the five groups outlined in section A will have a separate maximization problem. In this section we define each agent type’s optimization problem and characterize their solutions. Agents’ repayment decisions will depend on the relative value of being in
Figure A.2: Foreclosure Law and the Decision Problem of Owner-Occupiers

NOTE. Figure shows how the decision problem for a typical owner-occupier is affected by foreclosure law. Beginning from the left-most node, the owner realizes the housing shock and inherits a stock $H_0$ from the previous period. The owner must then decide whether to pay the mortgage or default; if he pays the mortgage he realizes another housing shock and returns to the first node. If he defaults he enters foreclosure. He remains in the property each period with probability $k$; with probability $1 - k$ he is evicted and must rent housing from then forward.

Appendix to “The Price of Protection,” Page 5
foreclosure as opposed to having good credit, so we will define those value functions first. Agents’ housing and effort decisions in the first period of life will depend on all subsequent possibilities, so we will define that value function last.

A.3.1 Value of Perfect Capital Markets

Agents who do not default at the beginning of the second period of life immediately gain access to perfect capital markets. Lenders do not have to fear default from these agents, so they will not charge a credit spread. None of these agents will choose to rent (because, as we shall see, renting carries a higher user cost of housing).

The value function of an owner-occupier of type $j$ with good credit who begins the period with housing of value $C_0$ is given by:

$$V^j(H_0) = \max_{\bar{h}, z, h_t, c_t} \mathbb{E}_0 \left\{ \sum_{t=1}^{\infty} \beta^{t-1} \left[ C_t + \sigma \log(h_t) - \frac{z^2}{2\alpha} \right] z_t \right\}$$

subject to: $\mathbb{E} \sum_{t=0}^{\infty} R^{-t} [Y^j + A_t - C_t + q(H_t - h_t) - P_t (H_t - H_{t-1})] \geq 0$.

Notice that the expectations in A.3 are taken conditional on effort $z$. Effort affects the amount of the housing stock owned by the household in the next period. Because the household has access to the expected present discounted value of all future endowments, the initial housing stock, $H_0$, has only as a pure wealth effect. In general the agent will use the capital markets to smooth housing consumption in the face of shocks. Thus we will write the value function of such agents usually as $V^j$, suppressing the argument.

Solving the household’s problem, equation (A.3), and assuming that prices are at a steady state (so that $P_t = P_{t+1} = P$), we find that the optimal choices of effort and housing stock each period, $z^*$ and $H^*$, satisfy:

$$H^* = \frac{1}{P} \frac{\sigma}{1 - \beta + \beta \theta (1 - z^*)}, \text{ and:}$$

$$z^* = \alpha \beta \theta PH^*.$$  

The term in the denominator of equation (A.4) can be interpreted as the user cost of housing in our model. The user cost of housing typically has three elements: interest payments, depreciation, and capital gains. Here the discount factor $\beta$ captures the time cost of money, the term $(1 - \tau) \theta$ captures (endogenous) depreciation, and, in the steady-state, capital gains collapse to zero.

If all capital markets were perfect (even for agents in the first period of their lives) we could solve equations (A.4) and (A.5) to determine the demand curve for housing,
By specifying a fixed level of the housing stock we can then determine steady-state equilibrium prices and effort if there is no default option. These are:

\[
PH = \frac{1}{2} \left\{ \frac{1}{\alpha} \frac{1 - \beta + \beta \theta}{(\beta \theta)^2} - \sqrt{\left[ \frac{1}{\alpha} \frac{1 - \beta + \beta \theta}{(\beta \theta)^2} \right]^2 - \frac{1}{\alpha} \frac{4 \sigma}{(\beta \theta)^2}} \right\},
\]

For any given constant level of the housing stock, \( H \), the steady-state equilibrium price can be found by dividing both sides of equation (A.6) by \( H \). We will take \( H = 1 \), so the right hand side of equation (A.6) gives the equilibrium price if default is not allowed.

### A.3.2 Value of Being a Renter

By assumption, the rental market is anonymous and renters cannot be punished for damage to the rental property. Further, the shock occurs after the renter leaves the property, so he has no incentive to work, sets \( z = 0 \), and the bad shock occurs with certainty. Thus renters will pay a rental rate \( q \) that is greater than the amount received by landlords, \( \overline{q} \). In a competitive equilibrium, rental rates are determined by the system of equations:

\[
q_t = (1 - \theta) \overline{q}_t, \text{ and:}
\]

\[
P_t = q_t + \frac{1}{R} (1 - \theta) P_{t+1}.
\]

Equation (A.9) determines the rental rate in period \( t \) at which owners are indifferent between selling now and renting now and selling tomorrow. In the steady-state, when \( P_t = P_{t+1} = P \), these conditions can be rewritten as:

\[
q = \frac{r + \theta}{1 + r} P, \text{ where } R \equiv 1 + r, \text{ and:}
\]

\[
\overline{q} = \frac{1}{1 - \theta} \frac{r + \theta}{1 + r} P.
\]

Notice that the user cost of housing for a renter, \( \overline{q} \), exceeds the user cost of housing for an owner-occupier, the denominator in equation (A.4).

\[23\] In reality, of course, renters often have to deposit a sum of money (usually one month’s rent) to cover any damage beyond normal depreciation to a rental property. As long as the bad shock, \( \theta \), routinely exceeds the deposit amount all of the results go through unchanged (except for the addition of even more notation).
The value function of an agent of type \( j \) who is forced to rent is:

\[
\Omega^j = \max_h \{ \sigma \log(h) + Y^j - \bar{q}h + \beta \Omega^j \}.
\]

Such agents will want to spend an amount \( \sigma \) on housing each period; however, poor agents (those with incomes \( Y^j < \sigma \)) will spend their entire endowment on housing. Thus we can rewrite the value function as:

\[
\Omega^j = \frac{1}{1 - \beta} \omega^j, \quad \text{where:} \quad \omega^j = \begin{cases} 
\sigma \log\left(\frac{Y^j}{\bar{q}}\right) & \text{if } Y^j \leq \sigma \\
\sigma \log\left(\frac{\sigma}{\bar{q}}\right) + Y^j - \sigma & \text{if } Y^j \geq \sigma.
\end{cases}
\]

### A.3.3 Agents in Foreclosure

An agent enters foreclose following a default on a mortgage. During the foreclosure process, the agent remains in possession of the original house until he is either evicted or chooses to depart voluntarily. If the house suffers the bad shock the agent cannot augment it. Thus, in period \( t \) the house will have suffered \( i \) bad shocks, where \( i = 0, 1, \ldots, t \). We can thus write the agent’s value function as:

\[
W(H) = \sum_{t=0}^{\infty} (k\beta)^t \left\{ \sum_{i=0}^{t} \pi(i, t)w(i) \right\} + \beta \frac{1 - k}{1 - k\beta} \Omega^j.
\]

Here \( w(i) \) is the agent’s one-period utility function if he has suffered \( i \) bad shocks since defaulting and has not been evicted (although he may choose to vacate the property voluntarily and become a renter).

Given an initial size of the house, \( H_0 \), the size of the house in any subsequent period \( t \) can be thought of as a the result of a sequence of \( t + 1 \) Bernoulli trials. Thus \( H_t \) must lie in the set:

\[
H_t \in \left\{ H_0, (1 - \theta)H_0, (1 - \theta)^2H_0, \ldots, (1 - \theta)^tH_0 \right\}.
\]

If a tenant is in foreclosure long enough, and the property suffers a series of bad shocks, \( H \) may drop so low that the tenant chooses to voluntarily vacate. Define \( h \) to be the value of \( H \) at which the agent voluntarily quits the house. Then as long as \( H > h/(1 - \theta) \) the agent will spend at least one more period (if not evicted) in the house.

In each period \( t \), the \( t + 1 \) terms \( w(0), \ldots, w(t) \) from equation (A.12) are each associated with a particular house size, \( H_t = H_0, \ldots, (1 - \theta)^tH_0 \). To characterize the \( w(i) \) terms we will divide them into two groups: first, those in which \( i \) is low enough so that the agent will stay in the property for at least one more period, even if he suffers the bad shock; and second, those in which \( i \) is so large that the agent will have already voluntarily left or will do so in the current period. Denote the critical value of \( i \) as \( p \), so that for
all values of \( i = 0, \ldots, p - 1 \) the agent will not vacate voluntarily, and for all values of \( i = p, \ldots, t \) the agent will vacate voluntarily (or has already done so). Notice that \( p \) is the smallest number of bad shocks required to reduce the initial housing stock to \( h/(1 - \theta) \):

\[
(1 - \theta)^{p-1}H_0 > \frac{h}{1 - \theta} \geq (1 - \theta)^pH_0, \text{ so:} \\
(1 - \theta)^p > \frac{h}{H_0} \geq (1 - \theta)^{p+1}.
\]

For all \( i \geq p \) we know that \( w(i) = \omega^j \), the one-period value of renting, from equation (A.11). We can then rewrite equation (A.12) as:

\[
W(H) = \sum_{t=0}^{\infty} (k\beta)^t \left\{ \min_{t,p-1} \pi(i, t)w(i) + \sum_{i=\min\{t,p\}}^{t} \pi(i, t)\omega^j \right\} + \beta \frac{1 - k}{1 - k\beta} \Omega^j.
\]

It remains to characterize the \( \pi(i, t) \) and \( w(i) \) terms. We defined \( w(i) \) as the one-period utility resulting from a house of size \( (1 - \theta)^iH_0 \) while in foreclosure:

\[(A.13) \quad w(i) = \sigma \log \left((1 - \theta)^iH_0\right) - \frac{z_i^2}{2\alpha}, \text{ where:} \]

\[
z_i = \arg\max -\frac{z_i^2}{2\alpha} + k\beta z_i w(i) + k\beta (1 - z_i) w(i + 1).
\]

The optimal effort expended at \( i, z_i \), is given by:

\[(A.14) \quad z_i = \alpha \beta k \left[w(i) - w(i + 1)\right], i = 1, \ldots, p - 1.\]

If the agent never voluntarily gave up tenancy in his house, \( z_i \) would be constant; that is, \( z_i \) would not depend on \( i \), because \( w(i) - w(i + 1) \) would just be:

\[(A.15) \quad w(i) - w(i + 1)|_{z_i = z_{i+1}} = -\log(1 - \theta), \quad i = 1, 2, \ldots, \infty.\]

However, when \( i = p \) the agent will vacate following the bad shock. His effort is then given by:

\[(A.16) \quad z_p = \alpha \beta k \left[w(p) - \omega^j\right].\]

Notice that the option to vacate the property lessens the incentive to work in the same way that the default option does; as a result, \( z_p \) will be lower than \( z_i \).

The value of \( z_p \) from equation (A.16) can be plugged into the definition of \( w(i) \), equation (A.13), when \( i = p \), to solve for \( w(p) \) purely in terms of model parameters. In particular, \( w(p) \) will be the rightmost solution to:

\[
w(p) = \sigma \log((1 - \theta)^pH_0) - \frac{\alpha}{2} \left[k\beta (w(p) - \omega^j)\right]^2.
\]

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With \( w(p) \) in hand, one can iterate backwards using equations (A.14) and (A.13) to compute \( w(i) \) and \( z_i \) at each successive stage.

There remains only to characterize the probabilities \( \pi(i, t) \). For states of nature featuring more than \( p + 1 \) bad shocks we can set the probabilities to zero without loss of generality, because in those states the agent is a renter. For all other states, the unconditional probability can be built up from the conditional probabilities. Let \( S(t - 1) \) denote the number of bad shocks realized at the end of period \( t - 1 \); then \( \pi(i, t) \) conditional on \( S(t - 1) \) is:

\[
\pi(i, t) \mid S(t - 1) = \begin{cases} 
0 & i = 0, \ldots, S(t - 1) - 1, \\
\bar{z}_{S(t-1)} & i = S(t - 1) \\
1 - \bar{z}_{S(t-1)} & i = S(t - 1) + 1 \\
0 & i = S(t - 1) + 2, \ldots, \min\{p + 1, t\}
\end{cases}
\]

We can simplify the analysis greatly if we assume that effort is constant unless the agent quits the premises voluntarily. As we demonstrated above, if the agent never voluntarily quits the property, optimal effort does not depend on the number of bad shocks. Thus, we note that the assumption of constant effort is (1) Not far off the mark, and (2) Will produce a value function \( \underline{W} \) that is weakly less than \( W \). If \( z_i = z = -\log(1 - \theta) \) all \( i \), then the agent’s value function can be written:

\[ W(H) \geq \underline{W}(H), \]

where \( \underline{W} \) is defined as:

\[(A.17) \quad \underline{W}(H) = \sum_{t=0}^{\infty} (k\beta)^t \left\{ M(t) \right\} + \beta \frac{1 - k}{1 - k\beta} \Omega^i, \text{ where:} \]

\[ M(t) \equiv \sum_{i=0}^{\min\{p, t\}} \binom{t}{i} (1 - z)^i z^{t-1} \log((1 - \theta)^i H) + \sum_{i=p+1}^{t} \binom{t}{p} (1 - z)^p z^{t-p} \omega^i \]

The assumption that effort is constant guarantees that the house size is the result of a series of i.i.d. Bernoulli trials. In turn, this guarantees that the probability distribution of size of the house in any period \( t \) will be given by a binomial distribution.

When \( t \leq p \) there is no chance that the agent will voluntarily quit the property. In that case, \( M(t) \) is just the expected value of a binomial distribution:

\[ M(t) = \log(H) + (1 - z) \log(1 - \theta)t, \text{ for } t = 0, \ldots, p. \]

Beginning in period \( p + 1 \) there is some chance that the agent will quit voluntarily. Denote this probability \( P(t) \):

\[ P(t) = \left[ \int_{0}^{1-z} u^p (1 - u)^{t-p-1} \, du \right] \times \left[ \frac{t!}{(pt)(t - p - 1)!} \right]. \]
Thus for \( t \geq p + 1 \), \( M(t) \) can be written:

\[
M(t) = (1 - P(t)) \log(H) + P(t) \omega^i + E \{ i(t) | i(t) \leq p \} \log(1 - \theta), \text{ for } t = p + 1, p + 2, \ldots.
\]

Here \( i(t) \) is the number of bad shocks suffered by period \( t \). This expression is tedious to compute, but we can bound it from below by assuming that the agent never voluntarily quits the property. Under this assumption, we know that:

\[
M(t) \geq M(t) \equiv \log(H) + (1 - z) \log(1 - \theta)t, \text{ for all } t \geq 0.
\]

Substituting back, we have:

\[
\frac{W(H)}{1 - k_\beta} \geq \sum_{t=0}^{\infty} (k_\beta)^t \{ M(t) \} + \beta \frac{1 - k}{1 - k_\beta} \Omega^i.
\]

This in turn implies that:

\[
\frac{W(H)}{1 - k_\beta} \geq \log(H) + (1 + \log(1 - \theta)) \log(1 - \theta) \frac{k_\beta}{1 - k_\beta} + \beta \frac{1 - k}{1 - k_\beta} \Omega^i.
\]

### A.4 Parameter Restrictions

We will impose three restrictions on the model’s parameters designed to keep the problem interesting. First, we will assume that the utility cost of effort is high enough to prevent the equilibrium effort level from being \( z = 1 \). In other words, we will assume that the moral hazard problem is a binding constraint on agents. This condition boils down to a limit on the size of \( \alpha \):

\[
(A_1) \quad \alpha < \frac{1}{\sigma \theta}, \text{ where } \beta \equiv \frac{1}{1 + b}.
\]

This restriction requires that the utility cost of effort must grow roughly in proportion with the utility benefit of housing.

The second restriction is on the distribution of income. We will assume that no agent is too poor to afford the carrying cost of the first-best choice of housing. Because we are using a log-linear specification for utility the income elasticity of housing is zero: all agents desire to spend the same amount on housing no matter their income. However, the non-negativity constraint on consumption might bind, forcing poor households away from this choice. The poorest agent in this economy has a constant endowment stream of \( Y \). In order for this agent to meet his mortgage payment every month, we require that:

\[
(A_2) \quad Y \geq \frac{b}{1 + b} (PH)^*.
\]
Here, \((PH)^*\) is the equilibrium value of housing, defined in equations (A.6) and (A.7) in the appendix.

The final condition requires that the economy as a whole can afford the housing stock as a whole. Again, this condition is required because of the log-linear nature of preferences. If the economy as a whole is too poor to afford to buy the entire housing stock each period, not enough surplus funds will be available from rich households to finance the borrowing of poor households. This condition can then be written as:

\[
(PH)^* \leq \int_{\mathbb{Y}} y \, dF(y).
\]

### A.5 Budget Constraints of Agents

Each of these four types faces a slightly different budget constraint:

\[
\text{(BC1)} \quad A_{t+1}^i = R \left[ Y_t^i + A_t^i + q_i (H_t^i - h_t^i) - C_t^i \right],
\]

\[
\text{(BC2)} \quad D_t^i = \rho_t \left[ D_t^i - (Y_t^i - C_t^i) \right],
\]

\[
\text{(BC3)} \quad A_{t+1}^i = R \left[ Y_t^i + A_t^i - C_t^i \right], \quad \text{and:}
\]

\[
\text{(BC4)} \quad A_{t+1}^i = R \left[ Y_t^i + A_t^i - C_t^i - \bar{u}_t h_t^i \right].
\]

Note that the budget constraint for owner-occupiers, equation (BC2), does not allow the agent to sell his current home and purchase a new home. Changes in tenure choice can easily be integrated into equations (BC2) and (BC4); they are merely suppressed here for clarity.

### A.6 Effect of Foreclosure Law

From figure A.2 we see that being a renter is the terminal (and absorbing) state of an owner-occupier with a mortgage who defaults. For this reason we will begin our analysis of the effect of foreclosure law by deriving the value to being a renter. We will then be able to determine the value of being in foreclosure, and that, in turn, will allow us to show how the incentive compatibility constraint affects mortgage contracts.
A.6.1 Owner-Occupiers With Mortgages

The value function of a borrower who begins the period with a house of size $H_0$, endowment $Y^j$ and a mortgage of size $D$ can be written as:

\[
V(H_0, D, Y^j; P) = \max_{\text{repay, default}} \left\{ \max_{\frac{z}{h}} \sigma \log(H) + C_{\text{repay}} - \frac{z^2}{2\alpha} + \beta E[V(H', D', Y^j; P)|z] \right\},
\]

\[
\left\{ \max_{\frac{z}{h}} \sigma \log(H_0) + C_{\text{default}} - \frac{z^2}{2\alpha} + \beta E[W(H', Y^j)|z] \right\}.
\]

The borrower first realizes his housing shock, inheriting a house of size $H_0$ from the previous period. This will be smaller than the house originally bought by the borrower if he has suffered one or more bad housing shocks in the interim. Given the inherited housing stock, the borrower must decide whether or not to default. If he does default, his property enters foreclosure as described above. If not, the borrower chooses effort, realizes a new housing shock and begins again. In addition, the borrower directs his entire endowment to paying off his mortgage. Because the agent’s utility of consumption is linear, he has no desire to smooth consumption. Furthermore, if he has to pay even a small credit spread, his effective rate of return on saving (paying down his debt) will exceed his discount factor and the borrower will prefer to consumption no non-housing goods until his mortgage is paid off.

The decision to default can be boiled down to a simple comparison between the pecuniary gain of default (the increase in non-housing consumption) and the utility loss of default. Agents will default whenever the gain to doing so outweighs the cost:

\[
D - PH > \beta \left\{ V - W \right\}.
\]
A.7 Default Decision

\[ H_1 = H_0 \rightarrow \text{Repay} \quad \rightarrow \text{Income} + \text{Equity} + \beta \{ \text{Good credit} \} \]

\[ H_1 = (1 - \theta)H_0 \]

\[ \frac{-z_0^2}{2\alpha} \quad \text{prob} = \alpha \]

\[ \text{Repay} \rightarrow \text{Income} - \text{Loss} + \beta \{ \text{Good credit} \} \]

\[ \text{Default} \rightarrow \text{Income} + \beta \{ \text{Bad credit} \} \]