Home Ownership, Local Interactions, and Segregation*

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1. Introduction

Why is home-ownership important? Are bad neighborhoods, with homes in disrepair and unsafe streets, simply a reflection of the poverty of the residents, or are low rates of home-ownership a contributing factor? Is there a role for public policy? These questions are a major concern to governments and NGOs, which have long supported home-ownership. Sociologists and economists have found evidence of important spillovers within a community from home-ownership. But theoretical research on the decision to own or rent a home has ignored such spillovers (instead focusing on externalities between landlord and tenant), and does not confront the issue of the determination of the quality and composition of neighborhoods.[1] This lacuna in our understanding means that we cannot analyze policies that promote home ownership as a means to improve the quality of communities. A complete theory would explain the quality of a community as the outcome of the decisions of all households in a metropolitan area, taking into account the general equilibrium effects that inhere in this problem. The purpose of this paper is to construct a simple version of such a theory.

We study a model with spillovers, in which the appreciation of the price of a home depends on the investments that other community residents make in their homes. An investment that raises the expected value of one's own home by a dollar raises aggregate wealth by more than a dollar since other homes also rise in value. Because individual households ignore this spillover in making investment decisions, individual choices need not be socially optimal.

We obtain two main results. First, there may be multiple, Pareto-ranked equilibria in the fraction of homeowners in a community.[2] In the bad equilibrium, the fraction of home-owners is low and the expected appreciation of home prices is low because the fraction of home-owners is low. In the good equilibrium, high levels of home ownership and home improvement effort on the part of a large fraction of residents renders these choices optimal for the household. Thus, a temporary subsidy to home-ownership in a neighborhood can be

[1] Representative of this work are Henderson and Ioannides (1983) and the literature surveyed in Rosen (1985).

[2] Our model thus contributes to the burgeoning literature on coordination failures. A survey focusing on macroeconomics is Cooper (1999); a survey focusing on development economics is Hoff and Stiglitz (1999).

Pareto-improving. The model thus formalizes the idea, which seems to underlie some government actions, that a "critical mass" of home-owners can change the quality of a whole community. For example, in announcing the recent decision to award a Harlem neighborhood a grant to help finance row houses for low- and moderate-income home-owners, an April 16, 1998 New York Times article entitled "Dreams, and Now Hope, Among the Ruins," described the decision as follows:

> "it was the sheer number of new home-ownership development and retail projects that clinched the decision to award the community the $4.65 million grant.…'I'm a big believer in critical mass,' [HUD Secretary Andrew Cuomo] said. 'If you have a distressed neighborhood, and you do something very small, it doesn't turn around the dynamic.'"

We also obtain a striking result on community formation. We find that under plausible conditions, market forces will lead home-owners and renters to live in separate communities. This has implications for the way in which differences in incomes (which in our model imply differences in the cost of financing home equity) translate into differences in the quality of the community in which a household lives and raises its children. Recent empirical work calls attention to the role of neighborhoods in the transmission of inequality across generations (Jencks and Mayer, 1994). We are able to show that even if the poor do not have different preferences for housing than the rich and even if they internalize externalities no less than the rich do, rich and poor households may live in communities that exhibit very different social characteristics--the rich in a community with high levels of home-ownership and high levels of civic engagement, and the poor in a community with low levels of both.

Let us spell out the building blocks of our theory in more detail:

(a) *Capital markets are imperfect*. We assume that the interest rate for individual borrowers is higher than that for lenders.[3]

(b) *Home-ownership affects behavior and has persistent effects on the quality of homes in a neighborhood*. This reflects the consensus of a large empirical literature. Controlling for income, education, and other socioeconomic characteristics, home-

[3]If, on the contrary, there were perfect neoclassical capital markets--with no information asymmetries, transactions costs, or tax distortions, then household income would affect only the quantity of housing services consumed, not the form of the housing contract (rental vs. home-ownership).

owners are more likely than renters to participate in neighborhood and block associations (Cox, 1982, Rohe and Stegman, 1994, Rohe and Stewart, 1996), to vote in local elections (Verba et al., 1995), to become informed about their political leaders (Rohe and Weber, 1996, DiPasquale and Glaeser, 1998), and to contribute to collective actions to deal with threats to property values (Skogan).[4] Compared to absentee landlords, homeowners invest more in home maintenance and undertake home maintenance more frequently (Galster, 1987).

(c) *Actions that an individual household takes to improve the value of its home increase the return to others of taking similar actions*. Consider the following examples:

A. An individual improves the exterior physical appearance of his house.
B. An individual takes care to keep his home free of litter, pests, and weeds, and to report to the police those who paint graffiti or illegally dump wastes near his home.
C. An individual contacts a local government official to complain that municipal garbage collection on his street is inadequate, or that drugs are being sold, or that a bar near his home is contributing to litter, noise, and crime.
D. An individual quickly repairs damage caused by vandals
E. An individual tries to impose social sanctions (spreading negative gossip) on a neighbor who does not keep his home up to community standards.

Observe in each case that an individual's effort can yield a private return, but there is *strength in numbers:* when a greater number of residents take similar actions, each resident's individual payoff is higher. The mechanisms for this complementarity vary. In A, it may be adherence to community norms or the fact that it is difficult for an individual to increase the resale price of his home through his own investment if the neighborhood as a whole is viewed as undesirable.[5] In B, there are

[4]These findings do not appear to reflect merely the fact that people with unobservable characteristics that make them better citizens tend to choose home-ownership. Almost no differences are found between home-owners and renters with respect to voting in national elections (Verba et al., p. 453), participation in political party organizations and school groups (Reingold, 1995), or views on public issues or confidence in most major institutions (Rossi and Weber, 1996).

[5]In his case study of one metropolitan area, Anderson (1994, p. 27) observed: [T]hough owners might make numerous improvements to their dwelling, these changes by themselves

technological effects (weeds and pests spread) and sociological effects (criminals are emboldened if individual citizens do not respond to the first signs of disorder, as emphasized in Kelling and Wilson (1982). As one Tucson resident observed in *The Arizona Daily Star* (November 1999): "When an area has graffiti, people feel comfortable dumping debris, so [the area] just declines and declines." In case C, an individual resident may have little voice if there is no *institutional* voice in the community to ensure that the police and other government officials do their job[6]. Regarding D, sociologists have argued that if there is evidence in a community of vandalism, e.g., a broken window, prospective vandals will tend to see the "cost of crime" as low and that, in turn, will tend to increase the crime rate. In turn, "each new crime promotes psychological and physical withdrawal of residents from public life, which reduces vigilance within the neighborhood and undermines the capacity for collective organization, making additional criminal activity more likely" (Massey and Denton, 1993, p. 13). In this view, if all residents monitor their own property and quickly repair any damage caused by vandals, then the crime rate will be reduced and residents will in fact view the costs of vigilance as low. Finally, in E, strength in numbers arises because reputation effects are only as strong as the information flows that sustain them.[7]

We will represent these many forms of value-enhancing behavior by a single index, "home improvement effort" and, for simplicity, we will assume that it can take only one of two values. The fundamental element of our model is that the *relative* return to high effort (relative to low effort) is increasing in the fraction of households in a neighborhood who

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do not increase their value. Property values increase when the area itself is defined as desirable…" Galster, 1987 and Ioannides, 1996 find that investments in home maintenance and home improvement by neighboring homeowners are complements.

[6]See, for example, Medoff and Sklar, 1994, p. 72: "The community meeting was one of [the neighborhood association's] earliest lessons in power politics. Residents saw that by coming together in large numbers and demanding what they were rightfully entitled to, they could change their neighborhood for the better." See also Anderson, pp. 107, 109, for a description of a night vigil by residents to close down crack houses; and Skogan for a march by residents to close down a liquor store.

[7]Formal models include Cooter 1995 (complementarities in informal enforcement of social norms), diPasquale and Glaeser 1998 (complementarities in investment in social networks), Akerlof and Yellen 1994 (complementarities in citizen efforts to reduce crime), and Chwe 1999 (the strength of weak ties).

expend high effort. As emphasized above, this assumption is motivated by many different kinds of empirical studies, and can be derived from models focusing on a variety of different kinds of spillovers.

We begin in Section 2 of the paper by presenting a model of a single community. In any generation of households, each household chooses the amount of home equity to purchase and the level of home improvement effort to expend. High effort produces a surplus in the form of expected capital gains, but only residents with a sufficiently high equity stake in their home will have an incentive to expend high effort. There is a trade-off--if the household purchases sufficiently high home equity to have an incentive to expend high effort, then it will obtain the surplus, but it may have to borrow to finance the purchase. This means that a low-income household will want to become a homeowner only if the expected price appreciation is high enough to offset the costs of borrowing. When more households become homeowners who expend high effort, expected price appreciation is greater. There are multiple equilibria in the cut-off income level above which households become homeowners. There may exist a bad equilibrium where a minority fraction of households buy enough equity to put in high effort, the resulting spillovers are low, and this supports the majority decision to stay renters.

Inefficiency may arise because there is a divergence between an individual household's private return from its choice, and the social return. This also means that a restricted menu of home equity contracts (for example, zero equity or full home ownership) may be offered by each owner, no one has an incentive to experiment with a broader set of possible contracts, yet that broader set of contracts would make possible a Pareto-dominant equilibrium.

Section 3 of the paper allows for migration across communities. Now there is a third source of possible inefficiency: neighborhood choice. We derive conditions under which neighborhoods will be segregated by tenure and stratified by income. Households may end up in completely segregated neighborhoods even when this is inefficient, because there are decreasing returns to effort within a community.

2. A Single Community Housing Model

We consider a community consisting of single-family homes. Successive generations of

households flow in and out of this community over time. We model this in the following way.

A. People and Timing of Events

We divide time into discrete periods. A new generation of households move into the community at the beginning of a period, and move out of the community at the end of the period. The latter point in time also corresponds to the beginning of the next period, when the next generation of households move into the community. We think of a generation of households as being composed of families who move into the community when the family is formed, stay in the community during the working lives of the adults, and move away when the adults retire.[8]

In this ongoing life of a community, our study focuses on the behavior of a *particular* generation of households in a *single* time period. For simplicity, we assume that the number of households in every generation is the same as the number of housing units in the community. In particular, we take each generation of households, as well as the set of housing units in the community, to be a continuum of measure one. This specification makes every resident household *atomistic* with respect to the community of residents as a whole.

The households differ only in one respect – their (exogenous) income. We let y denote the income of a typical household for the period of its residence in the community. Across the continuum of households, we take y to be distributed according to some distribution function F(.) on an interval $\mathbf{Y} \equiv [Y^-, Y^+]$. Further, we let w denote the present value of a household's future income as calculated at the end of the period. For simplicity, we posit that w is the same for all households, so that the heterogeneity is only in terms of current income.[9]

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[8] It will be helpful to think of individuals as living for three periods: when young they live with their parents in a community chosen by the parents, as adults (with their own families) they live in a community of their choice (e.g., near their place of work), and as senior citizens they live in a retirement community. This story will motivate our utility specification for households in Section 2D.

[9] It can be easily checked that our results will hold if we allow for a household's future income w to be either a deterministic or a stochastic function of its current income y.

In the period under study, our analysis starts after the households have entered the community and have received their incomes y. Each household then selects a housing unit to live in and negotiates a *housing tenure contract* with its existing owner.[10] A tenure contract is a tuple $\{\alpha, \beta\}$, where $\alpha \in [0, 1]$ is the fraction of the home that a household "buys" for a payment of β. Over and above the right to reside in the home for the period, such a contract gives the household the right to α fraction of all future revenues generated by the home. We will refer to α as the amount of housing equity owned by a household. A "pure rental contract" has $\alpha = 0$, while a "pure ownership contract" has $\alpha = 1$.

After taking up residence in a home under some tenure contract, a household makes its borrowing/savings decision, and decides on its level of "home improvement effort". The returns to such effort is described in the next subsection; at this stage we simply posit that the level of this effort is not directly observable to any party other than the household, and so it cannot be pre-specified in a tenure contract. At the end of the period, the home is "sold" (to a next generation household), and the "sales proceeds" are divided up between the household and the previous owner according to the stipulation α in their tenure contract.[11]

B. The Quality of a Home

At the beginning of every period, each home in the community is endowed with some level of quality (security, state of repair, attractiveness of the neighborhood, etc.). In order to focus on the way that the choices of residents can give rise to heterogeneity in housing quality in a community, we assume that at the beginning of the period of our study, the quality level of each home is *identical* for all units in the community. We denote this common quality level by Q^0.

A resident household can expend effort in home improvement to add to this stock of

[10] The reader will soon recognize that to be consistent with our model of a long-lived community, we should allow for the fact that at the beginning of the period, a home may be "partially owned" by multiple owners. However, for the ease of presentation, we will tell the story *as if* a single owner held 100% equity in a home (while being cognizant of the alternative possibility in our formal analysis).

[11] We place the words *sold* and *sales proceeds* in quotes because the future household can also enter into a tenure contract with $0 < \alpha < 1$, which is intermediate between renting and buying.

quality. Specifically, each household chooses an action a from the set {e, n}, where e denotes high effort in home improvement and n denotes minimal effort. We let q(.) denote the *increment* to quality for any particular home. As discussed in the Introduction, we posit that for any particular home, q(.) depends on the resident household's effort, as well as the efforts of other residents in the community. So, defining x to be the fraction of households in the community that expend high effort, we assume that:[12]

Assumption 1. For all $x \in [0,1]$, (*a*) $q(e,x) > q(n,x)$, (*b*) $q_x(a, x) > 0$ for $a \in \{e,n\}$, and (*c*) $q_x(e, x) > q_x(n, x)$.

Part (*b*) of the assumption asserts the existence of a spillover effect – other residents' home improvement efforts enhance the quality of one's own home. Part (*c*) says that for a resident who expends high effort, the spillover is larger than that for a resident who expends low effort. Thus, there is *complementarity* in home improvement efforts of community residents. This will play a key role in our analysis of a community equilibrium. In the Introduction, we have elaborated on plausible scenarios in which such complementarity exists.

During its residence in its home, a household enjoys the quality level $Q^0 + q(.)$. At the end of the period, the home is endowed with a quality level $Q^1 = g(Q^0 + q(.))$. We assume that g(.) is strictly increasing, with $g(z) \leq z$ for all z. This implies that at least some of the increase in housing quality that is achieved in the current period *persists* in the future.

C. Housing Prices

The evolution of housing prices in the community will depend on the evolution of housing quality, which in turn will depend on the behavior of households. To keep our analysis simple, we take the following "prices" as primitives of our model.

Firstly, we take as primitive the "future price" function $\hat{P}(Q^1)$, which is the expected present value of a home of quality Q^1 as calculated at the end of the period, and assume that

[12] Since every household in the community is atomistic, from a particular household's point of view, x represents the number (measure) of all other households who expend high effort.

$\hat{P}'(.) > 0$. In the following analysis, we will use the notation P(a,x) to denote $\hat{P}(Q^1)$, where $Q^1 = g(Q^0 + q(a, x))$. This notation emphasizes that individual and community effort levels affect the future price of a home in the same way as they affect its current quality: $P(e,x) > P(n,x)$, $P_x(a,x) > 0$, and $P_x(e,x) > P_x(n,x)$. Secondly, we take as primitive the rental rate ρ for a housing unit at the beginning of the period. Since we have assumed that all units are of the same quality at this point in time, we posit that the rental rate ρ is the same for all homes.[13]

As ρ is the price of renting a home for the period, it bears no connection to the end-of-period price P(.). However, when a household considers buying a positive-equity tenure contract (i.e., one with $\alpha > 0$), it will have to take into account both these sets of prices. We model the process by which a household negotiates a tenure contract as follows. At the beginning of the period, each household selects a distinct home to move into under the rental contract $\{0, \rho\}$. It then can renegotiate and offer a positive-equity contract $\{\alpha > 0, \beta > \rho\}$ to the existing owner, who then can either accept or reject the offer. The outcome of this negotiation process (which is studied below) will depend on ρ and P(.), and will determine the cost of equity for the household.

D. Intertemporal Utility

We find it eminently reasonable to assume that all households desire intertemporal consumption smoothing, and face a credit market imperfection with respect to the cost of borrowing. We incorporate these assumptions in our model in a very simple manner by specifying the following features: (*a*) every household has a minimum subsistence requirement, and (*b*) there is a wedge between the saving and the borrowing rate. We formalize this in the following way.

Consider a household with income y. Suppose that it negotiates a tenure contract $\{\alpha,$

[13] We could derive this property of a common rental rate by studying many explicit trading mechanisms. For instance, if we posited that the households got to select their homes through an auction, this would yield a common rental rate $\rho^{auction}$ under which the renter would obtain all the surplus. Alternatively, if we considered a mechanism where each owner posted a rental price for their units, this would give rise to a common rental rate ρ^{posted} which would give all the surplus to the owners. It can be easily verified that any common rental rate $\rho \in [\rho^{auction}, \rho^{posted}]$ would be a Walrasian equilibrium price in our model, given the equality of the measure of housing units and of the potential residents.

$\beta\}$, borrows an amount b, and takes an action a. Then, if x is the fraction of high-effort households in the community, the household's intertemporal payoff is:

$$\begin{aligned} &[y - \beta + b] + [Q^0 + q(a,x) - a] + \delta\{w - R(b)b + \alpha P(a,x)\} \quad \text{if } y-\beta+b \geq 0, \\ &-\infty \quad \text{otherwise;} \end{aligned} \tag{1}$$

where δ is the discount factor, R(b) is the "gross rate of interest", and (for simplicity) a represents the disutility to a household from taking action a.[14] Further, we posit that the gross rate of interest function R(.) satisfies the following condition:

$$R(b) = \begin{cases} 1 + r_S & \text{for } b < 0, \\ 1 + r_B & \text{for } b > 0, \end{cases} \quad \text{with } 1 + r_S < 1/\delta < 1 + r_B. \tag{2}$$

Utility specification (1) is a very simple way of modelling a household's desire to smooth nondurable consumption. Treating the (unmodeled) consumption good as the numeraire, (1) posits a minimum subsistence level for this good (which for simplicity is normalized at zero) without which the household's utility is unboundedly low.[15] (2) specifies the existence of a simple form of credit market imperfection: when a household borrows, the gross interest rate is greater than its marginal rate of time preference. Let $C \equiv \delta(1+r_B) - 1 > 0$ denote the magnitude of this wedge. The wedge discourages borrowing, but if $\beta > y$, the household will have to borrow to meet its subsistence requirement in the current period. Given (1) and (2), it is easy to show that a household will optimally borrow the amount $\max\{\beta - y, 0\}$.

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[14] To interpret this two-period utility function, recall the story in footnote 8 where individuals live for three periods. Utility function (1) is relevant for a household of adults at the time that they start their careers. At that point, they have two periods ahead of them – working life, and retired life. Their first period utility derives from net income $[y - \beta + b]$ and from housing quality net of effort costs $[Q^0 + q(a,x) - a]$, and their second period utility derives from their future income $\{w - R(b)b + \alpha P(a,x)\}$.

[15] Utility specification (1) is silent about a household's payoff if it defaults on its debt in the future, or *equivalently*, if it cannot finance non-negative non-durable consumption in the future after repaying its debt. We will simply assume that when a household finds it optimal to borrow, it *will* be able to repay its debt. This assumption keeps the analysis simple, but can be relaxed at little cost.

E. Home-ownership and Home Improvement

As discussed in the Introduction, there is considerable evidence that home-ownership is a determinant of behavior (controlling for other attributes). We now formalize this idea.

We assume that high home improvement effort entails a current period cost to the household and a future return in the form of capital gains. In the current period, the net surplus from expending high effort (as opposed to low effort) is: $s_0(x) \equiv [q(e,x) - e] - [q(n,x) - n]$; the analogous net surplus in the future is: $s_1(x) \equiv P(e,x) - P(n,x)$. In present value terms, the total net surplus is thus: $S(x) \equiv s_0(x) + \delta s_1(x)$. We assume that

Assumption 2. $S(x) > 0$ and $s_0(x) < 0$ for all $x \in [0, 1]$.

From (1), for a household with equity share of α, the net return to expending high effort is $s_0(x) + \alpha\delta s_1(x)$. Assumption 2 says that this return is strictly increasing in α, with it being negative for a "pure renter" (for whom $\alpha = 0$) and positive for "pure home-owner" (for whom $\alpha = 1$). The assumption captures the fundamental incentive problem that a household faces in our model ? it will have an incentive to expend high effort if and only if it has a high enough stake in the asset value of its home. The level of that critical stake is $\alpha^*(x) \in (0, 1)$, where

$$\alpha^*(x) = -s_0(x)/\delta s_1(x). \tag{3}$$

Then, defining $a^0(\alpha, x)$ to be a household's optimal action when it holds an equity share α, we have that $\alpha^0(\alpha, x) = e$ for $\alpha \geq \alpha^*(x)$, and $a^0(\alpha, x) = n$ for $\alpha < \alpha^*(x)$.

We assume throughout, for expositional simplicity, that $\rho < Y^-$, so that no household has to borrow simply to pay the rent. Then, if a household with current income y stays renter (with $\alpha = 0$), it will expend only minimal effort ($a^0 = n$) and will have a lifetime payoff of

$$u^n(y,x,\rho) = [y - \rho] + [Q^0 + q(n,x) - n] + \delta w. \tag{4}$$

In this case, the (expected) present value payoff (calculated in the current period) to the

existing owner of the housing unit will be $[\rho + \delta P(n,x)]$.[16]

We now study the outcome of contract renegotiation by a household after it has accepted a rental contract $\{0, \rho\}$ for a particular home. As described in the previous subsection, the price of equity is determined by a take-it-or-leave-it offer by the household, with a status quo point of no renegotiation.[17] Then, for any equity level α, define $\beta^0(\alpha,x,\rho)$ to be the price of equity such that the existing owner gets the same payoff under $\{\alpha, \beta^0(.)\}$ as under $\{0, \rho\}$:

$$\beta^0(\alpha,x,\rho) + \delta[1-\alpha]P(a^0(\alpha,x), x) = \rho + \delta P(n,x).^{18} \quad (5)$$

If the household decides to buy α amount of equity, then it will offer the price $\beta^0(\alpha,x,\rho)$ and the owner will accept the renegotiated contract $\{\alpha, \beta^0(\alpha,x,\rho)\}$.[19]

Starting from $\{0, \rho\}$, how much equity should a household buy? That depends on the price of the critical level of equity $\alpha^*(x)$. Let β^* represent this price, i.e., let $\beta^*(x,\rho) \equiv \beta^0(\alpha = \alpha^*(x),x,\rho)$. We will refer to this as the *price of home-ownership* since, as will be shown below, once a household pays this price and buys the critical amount of equity, its subsequent behavior will be identical to that of a pure home-owner. It is easy to see that

$$\beta^*(x,\rho) = \rho + \alpha^*(x)\delta P(n,x) - S(x).^{20} \quad (6)$$

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[16] If there are multiple partial owners of the home, $[\rho + \delta P(n,x)]$ will be their aggregate payoff as long as they are (effectively) risk-neutral.

[17] The posited contract renegotiation process gives the household the entire surplus that is generated from renegotiation. Any alternative negotiation process will yield qualitatively similar results as long as under such a process, the household obtains *some* of the surplus that is generated.

[18] Left-hand side of (5) is the present value payoff to the owner under $\{\alpha, \beta^0(.)\}$. In calculating it, she recognizes that the household will expend that level of effort that is "sequentially optimal" for it.

[19] This will also be true when there are multiple existing owners of the home. Implicit in our model is the assumption that an owner cannot provide direct credit to the household at a rate more favorable than r_B; inter-agent trade in credit cannot undo the credit market imperfection.

[20] Note that if the owner holds the pessimistic view that the household will not expend

The lifetime payoff to a household with current income y after renegotiating to the tenure contract $\{\alpha^*(x), \beta^*(x,\rho)\}$ is thus

$$u^e(y,x,\rho) = u^n(y,x,\rho) + S(x) - \max\{C[\beta^*(x,\rho) - y], 0\}. \quad (7)$$

This payoff takes an intuitive form. Starting from $\{0, \rho\}$, there is a gain and a (potential) loss for the household in renegotiating to $\alpha^*(x)$. The gain is the net surplus $S(x)$, while there is a loss of $C[\beta^* - y]$ if the price of home-ownership exceeds the household's current income, so that the household is forced to borrow the difference $(\beta^* - y)$. There is thus a critical income level $y^*(x,\rho)$ such that the gain is equal to the loss:

$$y^*(x,\rho) = \beta^*(x,\rho) - S(x)/C. \quad (8)$$

We assume that given ρ, and for any x, when a household with income $y \geq y^*(x,\rho)$ borrows to finance the equity purchase of $\alpha^*(x)$, its future earnings are enough to repay its loan.[21]

The above arguments establish the following result which characterizes a household's optimal decisions regarding tenure and home improvement.

Result 1: Given a level of community effort x, and the rental rate ρ, for a household with current income y: (*a*) if $y < y^*(x,\rho)$, it buys too little equity ($\alpha < \alpha^*(x)$) and expends minimal effort, (*b*) if $y > y^*(x,\rho)$, it buys sufficient equity ($\alpha \geq \alpha^*(x)$) and expends high effort, and (*c*) if $y = y^*(x,\rho)$, it is indifferent between the above courses of action.[22] The

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high effort, she should charge $[\rho + \alpha^*(x)\delta P(n,x)]$ for equity level $\alpha^*(x)$. However, once the household buys $\alpha^*(x)$, both parties recognize that it will put in high effort, and this leads to the discount $S(x)$.

[21] This guarantees that any household that finds it optimal to borrow does not default on its debt. If we did not make this assumption, and posited a future subsistence requirement, we would have a higher critical level of income at which a household would be indifferent between buying $\alpha^*(x)$ and staying renter. However, even then we would have the result (as in Result 1) that a household buys sufficient equity if and only if its income is above a critical level. That is all that is required for our analysis.

[22] Specifically, for any $y > \beta^*(x,\rho)$, the household is indifferent among $\alpha \in [\alpha^*(x), \min\{\alpha^+,1\}]$ where α^+ is such that $y = \beta^0(\alpha^+,x,\rho)$; for any $y \in (y^*(x,\rho), \beta^*(x,\rho)]$, it buys exactly $\alpha^*(x)$; and for any $y < y^*(x,\rho)$, it is indifferent among $\alpha \in [0, \alpha^-]$ where $\alpha^- < \alpha^*(x)$ is such that $y = \beta^0(\alpha^-,x,\rho)$.

household's maximized intertemporal payoff is: $u^*(y, x, \rho) = \max\{u^n(y, x, \rho), u^e(y, x, \rho)\}$.

Every household in our model recognizes the following incentive problem – it is better to be "enough of a home-owner" and obtain the surplus from home improvement. However, due to the capital market imperfection, the marginal cost of acquiring home equity is greater for a poorer household.[23] As a result, a household becomes a home-owner if and only if it is sufficiently rich. Due to the endogenous choice of contracts, even though low-income households do not have different preferences for housing quality than high-income households, and even though they internalize externalities no less than the latter do, the low- and high-income households behave differently – the rich home-owners making greater efforts towards home improvement than the poor renters. For ease of presentation, we will subsequently refer to a household that invests in home improvement (after buying sufficient equity) as a home-owner, and one that does not as a renter.

F. Community Equilibrium

Our objective is to study the properties of the equilibrium tenure choices of households with different income levels, and the concomitant distribution of housing quality in the community.

A community equilibrium in our model is completely described by the equilibrium fraction of home-owners, x*. Any fraction x of home-owners, and the common rental rate ρ, give rise to a unique cut-off income level $y^*(x,\rho)$ as defined in (8). This cut-off, given the income distribution, in turn determines the fraction of home-owners in the community. So,

[23] There are a variety of factors that raise the price of home equity for poor households, which are omitted from the model for brevity. These include tax subsidies to home-ownership (interest deductibility) and also the fact that higher loan-to-value ratios expose the lender to greater risk that the value of the collateral will fall below the principal and interest due. Another factor is that default risk due to income shocks is likely to be greater for the poor and thus generate higher transactions costs, which would then be reflected in higher interest rates charged.

given ρ, x^* is an equilibrium if and only if $\lim_{y \uparrow y^*(x^*,\rho)} F(y) \leq 1 - x^* \leq F(y^*(x^*,\rho))$.[24]

To determine the properties of a community equilibrium, we note, from (6) and (8), that

$$\partial y^*/\partial x = \{\delta P(n,x).d\alpha^*/dx - (1 + 1/C)S'(x)\} + \{\alpha^*(x)\delta P_x(n,x)\}. \quad (9)$$

The first bracketed term in the above expression is negative by Assumption 1(*c*), while the second term is positive by Assumption 1(*b*). With an increase in x, complementarity among residents' actions implies a fall in the level of the critical equity $\alpha^*(x)$[25], and an increase in the surplus S(x). Both these effects lower the price of home-ownership and thus y^*. On the other hand, the spillover effect implies that when x increases the owner's reservation price for the home goes up for every effort level, which increases the price of home-ownership and thus y^*.

We now argue that whether there can be one or many equilibria (in terms of the fraction of home-owners) in the community depends critically on whether or not y^* is an increasing function of x. Suppose that there are two equilibria x_1^* and x_2^* with $x_1^* > x_2^*$. Note that if $\partial y^*/\partial x \geq 0$ for all x, then $y^*(x_1^*,\rho) \geq y^*(x_2^*,\rho)$. But this implies that any household not investing at x_1^* (when the income cut-off is high) must not be investing at x_2^* (when the income cut-off is low), i.e. $x_1^* \leq x_2^*$, and we have a contradiction. This establishes that when y^* is increasing in x everywhere, there can be at most a single equilibrium fraction of home-owners in the community. However, if y^* decreases in x for *some* x, the above argument also indicates that there can be multiple equilibria in the community.

We collect the conclusions of the above analysis in the following result. The result

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[24] All households with $y < y^*$ buy insufficient equity, requiring the first inequality; and the largest measure of households buying insufficient equity can be all households with $y \leq y^*$, requiring the second inequality. The equilibrium condition allows for the existence of an atom in F(.) at $y^*(x,\rho)$.

[25] From (3), $d\alpha^*/dx = -\alpha^*(x)\{[(s_0'(x)/-s_0(x)] + [s_1'(x)/s_1(x)]\}$, which is strictly negative under Assumption 1(*c*). The complementarity effect implies that for a higher level of community effort, a household needs to own less equity in its home to have an incentive for home improvement.

asserts that a community equilibrium always exists. This follows from standard fixed-point arguments, and the "existence proof" is available from the authors upon request.

Result 2: Under Assumptions 1 and 2, a community equilibrium, defined by the fraction of home-owners, x*, exists for any given ρ. If $\partial y^*/\partial x \geq 0$ for all x, then the equilibrium is unique.[26] If not, then there can be multiple equilibria.

At this stage, it is important to recognize the following. If the complementarity effect in the community is sufficiently strong relative to the spillover effect, it will be the case that the cut-off income level y* decreases in x for some values of x. It is clear from (9) that for any given magnitude of the spillover effect on P(n,x), there exists a positive number ε such that if $s_t'(x) > \varepsilon$ for t = 0, 1, then $\partial y^*/\partial x < 0$ everywhere.[27] In our subsequent analysis we will assume this to be the case, and will identify it as Condition (*):

Condition (*): For all $x \in [0, 1]$, $\partial y^*/\partial x < 0$.

Result 2 states that when Condition (*) holds, there can be multiple equilibria in terms of tenure choices and residents' investments in home improvement. Furthermore, it is easy to establish (from (4), (7), and (8)) that for every household, its maximized intertemporal payoff $u^*(y,x,\rho)$ is strictly increasing in x when Condition (*) holds. This implies the following result.

Result 3: Suppose Condition (*) holds. If there are multiple equilibria in the community with different values of x*, these equilibria are Pareto ranked. All residents are strictly better off in an equilibrium with a higher fraction of home-owners as compared to one with a lower fraction.

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[26] This statement includes the "benchmark case" where community effort has no effect on the quality of an individual home, that is, where $q_x(a,x) = 0$. In that case, $\partial y^*/\partial x = 0$ for all x, and the equilibrium x* is uniquely determined by the income distribution function given the rental rate ρ.

[27] In our specification, community effort affects only the return from an individual household's effort in home improvement, and not the cost of making that effort. If, defining c(a,x) to be the disutility of effort a given x, we assume that $c_x(e,x) < c_x(n,x)$, this will increase the magnitude of the complementarity effect, $s_0'(x)$, without changing the magnitude of the spillover effect $P_x(n,x)$.

When the complementarity effect in the community is strong, the households face a coordination problem: if a large fraction of residents buy sufficient equity in their homes, the aggregate level of investment in home improvement will be high; in turn, this will encourage a large fraction of residents to buy equity in their homes. Result 3 indicates that any coordination failure has costs for each and every resident of the community. The existence of this coordination problem also predicts the following equilibrium correlation: a community with a higher proportion of home-owners should exhibit the feature that residents make higher levels of private investment towards their quality of life, and that the aggregate "community quality" is higher. As mentioned in the Introduction, there is evidence that such correlation is indeed observed across different communities in the US.

In Appendix A, we present a set of examples which demonstrate various features of community equilibria in our model. Example A1 demonstrates how there can be multiple equilibria in a single community when the complementarity effect is strong enough.

Given the possibility of multiple equilibria, it is of interest to enquire as to how the set of equilibria depends on the degree of income inequality among households. Within its specific structure, Example A1 provides an interesting answer to this question: The set of equilibria *shrinks* as the level of inequality increases. For low levels of inequality, all residents of the community (i.e., both rich and poor households)being home-owners is an equilibrium, as is all residents being renters. However, for high levels of inequality, the unique equilibrium outcome is one where all rich households are owners while all poor households are renters. So, while a decrease in inequality can be welfare-enhancing for community residents if they can coordinate on the Pareto optimal equilibrium, it can also make the cost of not being able to solve the coordination problem greater.

As mentioned in the Introduction, there is ongoing debate in the US as to how to encourage home-ownership by middle- and low-income households. The role of "housing subsidy" remains an important part of this debate. Our analysis emphasizes the following point regarding the efficacy of housing subsidy as an instrument to promote home-ownership. A housing subsidy can increase the proportion of home-owners in a community by eliminating certain Pareto inferior equilibrium outcomes. But it is important to note that "incremental" amounts of housing subsidy may fail to do so. In the context of Example A1, it can be easily established that there will exist a critical amount of subsidy that is required to make a difference. This is consistent with the recognition by some policy-makers like US

Secretary Cuomo of the existence of a "threshold effect".

3. Multiple Communities and Segregation

In the previous section, we have considered the case where all households of a particular generation choose their homes in a single community. In effect, such a specification implies that the interaction effects between residents exist over the entire metropolitan area where they live. However, in many real world scenarios, such interactions are more localized. There are multiple communities within a city, with there being significant local interaction effects within a community, and very little across communities. In this section, we extend our model to incorporate such a scenario where there are multiple communities in a metropolitan area, and where each household has to choose the community in which it wants to live. Within this structure, we study how different households sort themselves across communities.[28]

We let the metropolitan area consist of two communities, each having single-family homes of measure half. As before, a generation of households is of measure one, and current income y is distributed according to F(.) on $\mathbf{Y} \equiv [Y^-, Y^+]$. In the period of our study, each household has to choose one of the two communities to live in. A household's subsequent choices regarding tenure, home improvement, etc., are as described in Section 2, as is its payoff. As indicated above, we assume that Assumptions 1 and 2 hold for each of the two communities *individually*, and that there are no cross-community effects.

We assume that at the beginning of the period of our study, every home in community i (for i = 1, 2) is of the same quality level Q^0_i. Further, for our formal analysis, we make the stronger assumption that $Q^0_1 = Q^0_2$. As in Section 2, we make this assumption since we are interested in analyzing how differences in housing quality both within and across communities arise through household choices, starting from an initial situation of equality. However, we will subsequently indicate an implication of allowing Q^0_1 and Q^0_2 to be different.

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[28] Our model is similar to the model used by Benabou (1994, 1996) to analyze stratification in a metropolitan area. But his model treats the household's "type" as a datum, whereas in our model, a household's "type" is its endogenous tenure choice (or, equivalently, its home improvement effort level) which depends both on its income and on the characteristics of the community in which it resides.

For any community i, define x_i to be the fraction of resident households who are home-owners (i.e., who expend high home improvement effort), ρ_i to be the (common) rental rate, and $\mathbf{Y}_i$ to be the set of incomes y such that household y resides in community i. In this two-community model, we take the following prices as primitives: (*a*) the beginning-of-period common rental rate $\rho_1^* \in (0, Y^-)$ for each home in community 1, and (*b*) the end-of-period present value of a home in community i, $P(a, x_i)$.[29] A two-community equilibrium is a vector $\{\rho_2^*, (x_1^*, \mathbf{Y}_1^*), (x_2^*, \mathbf{Y}_2^*)\}$ which satisfies the following conditions: (1) $\mathbf{Y}_1^*$ and $\mathbf{Y}_2^*$ are partitions of $\mathbf{Y}$ such that the measure of households with income $y \in \mathbf{Y}_i$ (for i = 1, 2) is half; (2) given ρ_i^* in community i, x_i^* is a community equilibrium as described in Section 2; and (3) for all $y \in \mathbf{Y}_i^*$, $u^*(y, x_i^*, \rho_i^*) \geq u^*(y, x_j^*, \rho_j^*)$ for $j \neq i$, with $u^*(.)$ as defined in Result 1.

Our objective is to determine conditions under which there will be segregation in a two-community equilibrium, either in terms of tenure choice (segregation of owners and renters) or in terms of income (segregation of the rich and the poor). As mentioned in the Introduction, there is some evidence of such segregation across communities in the US. We will say that an equilibrium exhibits "tenure segregation" if across the two communities either all owners live in the same community, or all renters live in the same community, or both.[30] An equilibrium will be said to exhibit "income segregation" if all residents of one community are richer, in that their current incomes y are (weakly) greater, than all residents of the other community.

We begin by delineating a special class of equilibria in the two-community model which do not exhibit either tenure- or income-segregation. These are the *symmetric equilibria* where the fraction of home-owners in a community is the same across the two communities: $x_1^* = x_2^*$.[31] Under our assumption that the initial quality of all homes are the

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[29] In this two-community model, once the current-period rental rate in one of the communities is taken as given, the (common) rental rate in the other community will be determined in equilibrium.

[30] If all residents across the two communities make the same tenure choice in equilibrium (i.e., if either $x_1^* = x_2^* = 0$ or $x_1^* = x_2^* = 1$), we will say that there is no tenure segregation in equilibrium.

[31] Obviously, such an equilibrium does not exhibit tenure segregation. Further, it must have $\rho_2^* = \rho_1^*$, and thus $y^*(x_1^*, \rho_1^*) = y^*(x_2^*, \rho_2^*)$. Then, if $x_1^* = x_2^* \in (0, 1)$, all

same, the next result establishes that any such equilibrium is a "replication" of a single-community equilibrium (where the latter refers to our single-community model with the community having a continuum of homes of measure one). Proofs of all results in this section are presented in Appendix B.

Result 4: Given $Q^0_1 = Q^0_2 = Q^0$, there exists an equilibrium with $x_1^* = x_2^* = x^*$ in the two-community model if and only if x^* is a single-community equilibrium given Q^0 and ρ_1^*.

Result 4 indicates that within the structure of our model, there can exist equilibria in a multi-community model where there is no segregation. This is the case when the equilibrium outcome in each of the communities is a mirror image of what would happen in equilibrium if the communities were "merged" into a single one. However, as our next result shows, such symmetric equilibria are not "robust" in a specific sense.

Result 5: If $Q^0_1 \neq Q^0_2$, then generically (for arbitrary income distribution functions F(.)), an "interior" symmetric two-community equilibrium (i.e., with common $x^* \in (0, 1)$) cannot exist.

The intuition behind Result 5 is as follows. When initial housing quality is identical for all homes, i.e., $Q^0_1 = Q^0_2$, every symmetric equilibrium has the feature that all home-owners (across the two communities) are indifferent as to which community they live in. This allows one to take the total set of all households who want to be owners and equally divide them across the communities. However, when $Q^0_1 \neq Q^0_2$, this indifference property is lost, and generically, it is not possible to find equal-sized sets of home-owners for each of the two communities.[32]

Given the above result, we now turn our attention to studying *asymmetric equilibria* in the two-community model, where the fraction of home-owners in a community differ across the two communities. Our aim is to determine conditions under which such equilibria

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owners in community 1 are richer than all renters in community 2, and *vice versa*, and there is no income segregation.

[32] Even when $Q^0_1 \neq Q^0_2$, a symmetric equilibrium with either $x^* = 0$ or $x^* = 1$ is not necessarily unstable. However, note that in the class of symmetric equilibria, it is only in "interior" equilibria that all households do not make the same tenure choice. So, given our interest in studying segregation, this is the interesting class of equilibria to focus on.

exhibit segregation. In the following analysis, we will maintain the assumption that $Q^0_1 = Q^0_2$, and without loss of generality, we will consider the case where $x_1^* > x_2^*$.

We present a condition under which an asymmetric equilibrium in the two-community model must exhibit tenure segregation:

Condition (**): For all $x \in [0,1]$, $-\partial y^*/\partial x > q_x(n,x)$.

Condition (**) is a strengthening of Condition (*) (in Section 2F) – it not only requires that the complementarity effect be strong so that the cut-off income level y* is strictly decreasing in x, but that it be strong enough so that the magnitude of this decline is greater than the magnitude of the spillover effect on q(n,x).

Result 6: Assume that Condition (**) holds. Then every asymmetric equilibrium in the two-community model exhibits tenure segregation.

The intuition behind the above result is as follows. Let us start from a situation of no tenure segregation where there are home-owners and renters in both communities with $1 > x_1 > x_2 > 0$. Then given that community effort is greater in community 1, why wouldn't the home-owners in community 2 prefer to move? The only reason could be that the cost of home-ownership is higher in community 1 (one fact contributing to this is that ρ_1 must be higher than ρ_2 for there to be renters in both communities). However, Condition (**) ensures that that would not be the case in this scenario, and so home-owners in community 2 would indeed want to relocate. This would result in tenure segregation.

Result 6 states that in a multi-community world, when the complementarity effect of neighbors' efforts is sufficiently stronger than the spillover effect, home-owners will indeed want to reside together.[33] What if the former effect is not that strong? Example A2 in Appendix A shows that if Condition (**) does not hold, there can exist asymmetric equilibria in two-community model which are not tenure segregated.

For our subsequent analysis, we will maintain that Condition (**) holds. Then

[33] Note that for any given magnitudes of the complementarity effect, $s_t'(x)$, there exists an $\chi > 0$, such that if the magnitude of the spillover effect, $q_x(n,x)$, is smaller than χ, Condition (**) will hold.

Result 6 implies that asymmetric equilibria in the two-community model can be of three kinds. Firstly, there can be equilibria with $x_1^* \in (0, 1)$ and $x_2^* = 0$, where it is only the owners who are concentrated in a single community. We will call such an equilibrium to be "owner stratified". Secondly, there can be "renter stratified" equilibria with $x_1^* = 1$ and $x_2^* \in (0, 1)$, where it is only the renters who are concentrated in a single community. And finally, there can be equilibria with $x_1^* = 1$ and $x_2^* = 0$, which are "completely stratified".

We now ask the question: Will the three kinds of tenure segregated equilibria described above also exhibit income segregation? We begin by considering an example, Example A3 in Appendix A, where a tenure segregated equilibrium is *not* income segregated. In this example, in equilibrium, all middle-income households (whose measure is half) are home-owners in community 1, while all high- and low-income households (each of whose measure is a quarter) live in community 2 with the former being home-owners and the latter being renters. There are two special features of this example which make such an equilibrium outcome possible. Firstly, the income distribution is such that the equilibrium is renter stratified. And secondly, the high-income households are so rich that they do not have to borrow to finance the purchase of their housing equity. Recognizing these features of Example A3, the following analysis presents sufficient conditions under which there can be income segregation in equilibrium.

We partition $\mathbf{Y} \equiv [Y^-, Y^+]$ into two sets, $\mathbf{Y}^H$ and $\mathbf{Y}^L$, such that the measures of households with income $y \in \mathbf{Y}^H$ and households with income $y \in \mathbf{Y}^L$ are each half, and that $y' \geq y''$ for all $y' \in \mathbf{Y}^H$ and $y'' \in \mathbf{Y}^L$. We define the income level Y^m to be the infimum of the set $\mathbf{Y}^H$.[34] Recognize that if a two-community equilibrium is to be income segregated, it must be that all households with current incomes in $\mathbf{Y}^H$ live in one community, while those with current incomes in $\mathbf{Y}^L$ live in the other.

Our next result states that as long as an asymmetric equilibrium is not renter segregated, it can be "supported" as an income segregated equilibrium in the following sense.

Result 7: Assume that Condition (**) holds. Suppose that there exists a two-community equilibrium with $x_1^* \in (0, 1]$ and $x_2^* = 0$. Then there exists an equilibrium with the same

[34] Note the following: Firstly, the sets $\mathbf{Y}^H$ and $\mathbf{Y}^L$ are unique (up to sets of measure zero under F). Secondly, $y' \geq Y^m \geq y''$ for all $y' \in \mathbf{Y}^H$ and $y'' \in \mathbf{Y}^L$. And finally, if the *median income* in $\mathbf{Y}$ under F is unique, then it equals Y^m.

(x_1*, x_2*) pair (and the same rental rates) where $\mathbf{Y}_1$* = $\mathbf{Y}^H$ and $\mathbf{Y}_2$* = $\mathbf{Y}^L$.

In words, Result 7 says the following: Consider a two-community equilibrium which is either owner stratified or completely stratified. While this equilibrium need not necessarily exhibit income segregation, there will exist another equilibrium with the same outcome (in terms of the fractions of home-owners in each of the two communities), where all community 1 residents will be (weakly) richer than all community 2 residents.

The intuition behind Result 7 is as follows. In an owner stratified equilibrium, all renters are indifferent as to which community they rent in. So, it can be that some renters in community 2 are richer than some renters in community 1, thereby violating income segregation. However, as they are indifferent between the two communities, they can be "appropriately relocated" so as to generate income segregation.

Next, consider a completely stratified equilibrium. There, a household with income $y' > Y^m$ can be renting in community 2 and a household with income $y'' < Y^m$ can be owning in community 1, thereby violating tenure segregation. However, this can happen if and only if the following are true: (*a*) both households are indifferent between owning in community 1 and renting in community 2, and (*b*) both households are rich enough so that they would not have to borrow to finance home equity purchase if they wanted to be home-owners in community 1. The former result implies that the households can be relocated so as to generate income segregation. The latter result allows us to assert the following corollary to Result 7: Suppose Condition (**) holds, and suppose that $Y^m < \beta^*(1,\rho_1^*)$, i.e., a household with income Y^m needs to borrow to finance home equity in community 1. Then any completely stratified equilibrium must exhibit income segregation.

It is not implausible to assume that $Y^m < \beta^*(1,\rho_1^*)$. In fact, given that in the real world almost all households take *some* mortgage when buying a home, it may be reasonable to assume the following in the context of our model: $Y^+ < \beta^*(1,\rho_1^*)$, i.e., every household, no matter how rich it is, needs to borrow to finance home equity. If we do assume this (in contrast to our specification in Example A3), we have the result that every renter stratified equilibrium in the two-community model can be supported as an income segregated equilibrium.

Result 8: Assume that Condition (**) holds, and that $Y^+ < \beta^*(1,\rho_1^*)$. Suppose that a two-community equilibrium with $x_1^* = 1$ and $x_2^* \in (0, 1)$ exists. Then there exists an

equilibrium with the same (x_1*, x_2*) pair (and the same rental rates) where $\mathbf{Y}_1^* = \mathbf{Y}^H$ and $\mathbf{Y}_2^* = \mathbf{Y}^L$.[35]

The above results lead to the following general conclusion: When the complementarity effect in a community is sufficiently stronger than the spillover effect (so that Condition (**) holds), its direct consequence is that every asymmetric equilibrium in a multi-community world exhibits tenure segregation. On the other hand, every such equilibrium is not necessarily income segregated. However, under the plausible assumption that any household desiring to own a home has to take out a mortgage, the phenomenon of income segregation is "consistent" with such equilibrium outcomes (in the sense made precise in Results 7 and 8).

4. Conclusion

This paper provides one model of the mechanisms through which externalities associated with home-ownership work. It shows that in a setting in which home-ownership resolves a moral hazard problem and low-wealth households face high transactions cost in the credit market, it is possible that communities with very different social structures "self-organize," with the rich in communities with high home-ownership and high community engagement, and the poor in communities with low levels of both.

We should note that an important factor contributing to residents' investments in their homes and communities is residential stability. diPasquale and Glaeser (1998) find that the lower mobility of homeowners contributes importantly to the difference in behavior between homeowners and renters. Compared to homeowners, who face high transactions costs of moving, renters are more likely to choose to leave when neighborhood conditions *worsen*. When conditions *improve*, land rents increase and renters are more likely to be unable to afford to live in the neighbor they helped create. Our model abstracts from these factors by assuming that exogenous life cycle events determine mobility. Incorporating these factors would strengthen most of the results of the paper, since these factors provide additional

[35] Again, the intuition is as follows: When a renter stratified equilibrium is not income segregated, the households "responsible" for this have incomes such that they are indifferent between owning in either community. Then they can be appropriately relocated so as to maintain the equilibrium fractions of home-owners in the two communities, and generate income segregation.

incentives--besides their asset stake--for homeowners to take the "long" view of the return to home improvement efforts.

Two other limitations of our analysis should be mentioned. Our analysis does not apply where a household can own an arbitrarily low-cost home. In that case, low income would be no bar to ownership. It also does not apply where residents are so wealthy that they are able and willing to buy the kind of services that we have implicitly assumed only residents can provide. If residents, both homeowners and renters, prefer to pay for such services through the market or, as in many European countries, to support a high level of public services provided by the national government, then home-ownership and "community quality," in the sense in which that term is used here, will no longer be linked. Rental units that serve a wealthy clientele do provide janitorial and security services, and the rules which they often impose on residents provide a substitute for community-generated and policed standards of behavior.

But where ownership entails a "lumpy" capital investment and where the cost is prohibitive of purchasing a substitute for residents' home improvement efforts, the model suggests that reforms in the housing market to permit residents to own a share of the equity of their homes may hold some promise in easing the plight of troubled, crime-ridden communities and expanding the self-help capacity of the poor. Temporary subsidies to home-ownership, such as the U.S. has undertaken in selling off public housing projects to long-term residents, may also be able to play a role in permanently improving communities.

The theory presented in this paper can be taken as a kind of "parable of capitalism," where individuals' decisions to purchase equity affect their efforts, which then affect the payoffs to others. The theory applies to a variety of other situations, for example, the choice between entrepreneurship and wage-earning and the formation of industrial belts. For example, suppose that each firm is managed either by a wage-earner or by someone with an equity stake in the firm (an "entrepreneur"). Suppose also that only entrepreneurs with a sufficiently high equity stake in the firm will have an incentive to expend high effort; there is moral hazard in the supply of effort. Consider a situation in which all individuals are intrinsically the same, but differ in (inherited) wealth. Each individual in a given generation chooses whether to become an entrepreneur or a salaried manager, employed by a member of the older generation. Because of credit market imperfections and because entrepreneurship requires purchasing an equity stake, an individual with lower initial wealth faces a higher cost of becoming an entrepreneur. But entrepreneurs have stronger incentives and so produce

greater surplus. Moreover, their efforts have spillovers; over some range these spillovers increase the payoffs to entrepreneurs more than those to salaried managers.[36] When these feedback effects are present, again, just as in the model of home-ownership in a residential community, there may be multiple equilibria in the threshold wealth level above which an individual will choose to become an entrepreneur; and there may be stratification of entrepreneurial firms in industrial belts. We intend to examine these applications in future work.

[36]For evidence of local spillovers across firms, see Henderson (1995) and Wallsten (1999).

Appendix A

This Appendix presents a set of examples that demonstrate various features of community equilibria in our model.

Example A1

This example demonstrates how there can be multiple equilibria in a single community when the complementarity effect is strong enough. The example also illustrates the way in which the distribution of income "maps" into community equilibria.

We posit a very simple structure of income distribution. Half the population of households are `rich' with per period income $Y + z$, and the other half are `poor' with per period income $Y - z$, with $z \in (0, Y)$. Note that the mean income of the population is Y, and that z is a measure of the extent of income inequality in the population. In this example, we will be interested in looking at the set of community equilibria for a given value of z, and in determining how this set changes as z changes. We will not be explicit about the functional forms of q(.) and P(.), but will simply posit that $\partial y^*/\partial x < 0$ so that the following chain of inequalities hold (we hold fixed the initial rental rate ρ, and abuse notation to denote the cut-off income level $y^*(x, \rho)$ by $y^*(x)$):

$$2Y > y^*(x=0) > y^*(x=0.5) > Y > y^*(x=1) > 0. \qquad (14)$$

Define z_0 such that $Y + z_0 = y^*(0)$; $z_{0.5}$ such that $Y + z_{0.5} = y^*(0.5)$; and z_1 such that $Y - z_1 = y^*(1)$. Note that $z_0 > z_{0.5}$, and the inequalities in (14) imply that z_0, $z_{0.5}$, and z_1 are all strictly between 0 and Y.

Given the above structure, the following results are easy to establish: (1) $x^* = 0$ is a community equilibrium if and only if $z \leq z_0$. (2) $x^* = 0.5$ is an equilibrium if and only if $z \geq z_{0.5}$. (3) $x^* = 1$ is an equilibrium if and only if $z \leq z_1$. (4) An $x^* \in (0, 0.5)$ is an equilibrium if and only if $z \in (z_{0.5}, z_0)$. (5) An $x^* \in (0.5, 1)$ is an equilibrium if and only if $z < z_1$.

The above results enable us to determine the set of community equilibria for every value of $z \in (0, Y)$. Consider the case where $z_1 \in (z_{0.5}, z_0)$. Here, there are multiple equilibria for all values of $z \in (0, z^0]$. For small levels of income inequality, i.e., $z \in (0,$

$z_{0.5}$), all households becoming home-owners is an equilibrium outcome, as is all households staying renters. For a higher level of income inequality, i.e., $z \in (z_?, z_1)$, in addition to the above two equilibrium outcomes, there is a community equilibrium where only the rich become home-owners. This latter outcome is the unique equilibrium outcome when income inequality is very high, i.e., when $z > z^0$.

Example A2

This example shows that when Condition (**) is not satisfied, there can exist asymmetric two-community equilibria which are not tenure segregated. We consider the following income distribution structure: there are positive measures of high-, middle-, and low-income households. Let y_H denote the high-income level, y_M the middle-income level, and y_L the low-income level; and let μ_j (> 0) denote the measure of households with income level j, for j = H, M, L. We posit that $0.5 > \mu_H > \mu_M$. Our proposed equilibrium has the following outcome: All high-income households are home-owners in community 1, all middle-income households are home-owners in community 2, and all low-income households are renters across the two communities. This is a non-segregated outcome with $1 > x_1 = 2\mu_H > x_2 = 2\mu_M > 0$.

As there are renters in both communities in this outcome, the equilibrium rental rates have to satisfy: $\rho_1 - \rho_2 = q(n,x_1) - q(n,x_2)$. For i = 1,2, define $y^*_i = y^*(x_i,\rho_i)$, $\beta^*_i = \beta^*(x_i,\rho_i)$. Contrary to Condition (**), we posit that $y^*_1 > y^*_2$, but assume that $[y^*_1 - y^*_2]$ is small so that $\beta^*_2 > y^*_1$. Then, we have the following chain of inequalities: $\beta^*_1 > \beta_2 > y^*_1 > y_2^*$. Next, we posit that the three income levels satisfy the following conditions: $y_L < y_2^*$ so that a low-income household will rent in either community; $y_1^* < y_M < \beta^*(x_2,\rho_2)$ so that a middle-income household will be a credit-constrained owner in either community; and $y_H = \beta^*_1 - \varepsilon > \beta^*_2$ for some $\varepsilon > 0$ so that a high-income household will be an owner in either community and be credit-constrained in the former. Note that under these parameter specifications, for a small enough value of ε, the following are true: Each low-income household strictly prefers to rent and is indifferent between the two communities; each middle-income household strictly prefers to live in community 2; and each high-income household strictly prefers to live in community 1. Thus, under the posited parameter values, the proposed outcome is an equilibrium.

Example A3

This example shows how a tenure segregated equilibrium may not be income segregated. We consider the same income distribution structure as in Example A2, and posit that $\mu_H = \mu_L = 0.25$, while $\mu_M = 0.5$. Our proposed equilibrium has the following outcome: All middle-income households are home-owners in community 1, and in community 2, the high-income households are home-owners while the low-income households are renters. This outcome is tenure-segregated, with $1 = x_1 > x_2 = 0.5$, but it is not income-segregated.

Given the fixed community 1 rental rate ρ_1, define ρ' such that $\rho_1 - \rho' = [q(n,1) - q(n,0.5)] + [S(1) - S(0.5)]$. We posit that the complementarity effect is so strong that $y^*(0.5,\rho') = \beta^*(1,\rho_1)$. Then we have the following chain of inequalities: $\beta^*(0.5,\rho') > \beta^*(1,\rho_1) = y^*(0.5,\rho') > y^*(1,\rho_1)$. We posit that $y_H > \beta^*(0.5,\rho')$ so that a high-income household will be an owner in either community and will never have to borrow; $y_L < y^*(1,\rho_1)$ so that a low-income household will be a renter in either community; and $y_M \in (y^*(1,\rho_1), \beta^*(1,\rho_1))$ such that $C[y_M - y^*(1,\rho_1)] > S(1) - S(0.5)$ (which will be the case for y_M close to $\beta^*(1,\rho_1)$) so that a middle-income household will be a credit-constrained owner if put in community 1 and a renter if put in community 2.. Then it is easy to establish that for a community 2 rental rate $\rho_2 = \rho' - \varepsilon$, with ε (positive) sufficiently close to zero, our proposed outcome is an equilibrium where middle-income households strictly prefer to live in community 1, while high- and low-income households strictly prefer to live in community 2.

Appendix B

In this Appendix, we present the formal proofs of the results contained in Section 3. We will use the following notation in the proofs: given a two-community equilibrium, we will let $y_i^* \equiv y^*(x_i^*,\rho_i^*)$, $\beta_i^* \equiv \beta^*(x_i^*,\rho_i^*)$, $q_i^* = q(n,x_i^*)$, and $S_i^* = S(x_i^*)$. Further, we indicate one way of writing a household's maximized intertemporal payoff $u^*(y,x,\rho)$ which will be used in proving many of the following results. Given the definition of $u^*(.)$ in Result 1, note from (4), (6), (7), and (8) that, for $y \le y^*(x,\rho)$, $u^*(y, x, \rho) = u^n(y, x, \rho)$, and for $y > y^*(x,\rho)$, $u^*(y, x, \rho) = u^n(y, x, \rho) + \min\{C(y - y^*), S(x)\}$. Finally, we will use the notation $u_i^*(y)$ to denote household y's maximized intertemporal payoff when it resides in community i.

Proof of Result 4

Suppose x* is a single-community equilibrium given Q^0 and ρ_1^*. In this equilibrium, let **H***

be the set of home-owner incomes, and let $\mathbf{R}^*$ be the set of renter incomes. Let $\mathbf{H}_1^*$ and $\mathbf{H}_2^*$ be any equal-sized partition of $\mathbf{H}^*$, and let $\mathbf{R}_1^*$ and $\mathbf{R}_2^*$ be any equal-sized partition of $\mathbf{R}^*$. Then, setting $x_1^* = x_2^* = x^*$, $\rho_2^* = \rho_1^*$, $\mathbf{Y}_1^* = \mathbf{H}_1^* \cup \mathbf{R}_1^*$, and $\mathbf{Y}_1^* = \mathbf{H}_2^* \cup \mathbf{R}_2^*$, it is easy to show that $\{\rho_2^*, (x_1^*, \mathbf{Y}_1^*), (x_2^*, \mathbf{Y}_2^*)\}$ is a two-community equilibrium when $Q^0_1 = Q^0_2 = Q^0$.

Alternatively, given the common initial quality Q^0, consider any two-community equilibrium with $x_1^* = x_2^*$. It is easily proved that in such an equilibrium, it must be that $\rho_1^* = \rho_2^*$ (otherwise all residents would strictly prefer to live in the community with the lower rental rate). Then a single-community equilibrium can be constructed with $\rho = \rho_1^* = \rho_2^*$, and $x^* = x_1^* = x_2^*$, by essentially reversing the steps of the construction described above.

Proof of Result 5

Consider the case where $Q^0_1 > Q^0_2$. Here we will explicitly consider the dependence of P(.) on Q^0. Recall that $P(a,x; Q^0) \equiv \hat{P}(g(Q^0 + q(a,x)))$. This implies that $dP/dQ^0 = \hat{P}'.g' > 0$. We will assume that d^2P/dQ^2 is non-zero on its domain, but that its absolute value is small. For the surplus expressions, this implies that while s_0 is independent of Q^0, ds_1/dQ^0 is non-zero on its domain with small absolute value. This, in turn, implies that $dy^*/dQ^0 > 0$. (When the absolute value of d^2P/dQ^{02} is small, the positive effect of an increase in Q^0 on P dominates any negative effect in determining the sign of dy^*/dQ^0.)

Now suppose that there exists a two-community equilibrium with $x_1^* = x_2^* = x^*$, for some $x^* \in (0,1)$. Then there are renters in both communities, and this immediately implies that $\rho_1^* - \rho_2^* = Q^0_1 - Q^0_2 > 0$. Then it must be that $y_1^* > y_2^*$. Further, the total net surplus in the two communities, $S(x^*,Q^0_1)$ and $S(x^*,Q^0_2)$, will be distinct since d^2P/dQ^2 is non-zero. Then the following results can be established: All households with income $y < y_2^*$ strictly prefer to be renters and are indifferent between the two communities. For all households with income $y > y_2^*$, one of two cases arise. If $S(x^*,Q^0_1) < S(x^*,Q^0_2)$, then all such households strictly prefer to be home-owners in community 2. If $S(x^*,Q^0_1) > S(x^*,Q^0_2)$, there exists a $y' \in (y_1^*, \beta_1^*)$ such that all households with $y \in (y_2^*, y')$ strictly prefer to be home-owners in community 2, while all households with $y > y'$ strictly prefer to be home-owners in community 1. In the former case, it is obvious that $x_1^* = x_2^* = x^* \in (0, 1)$ cannot be an equilibrium. In the latter case, $x_1^* = x_2^* = x^*$ can be an equilibrium if

and only if there are two sets of households of equal measure such that one set prefers to be home-owners in community 1 while the other set prefers to be home-owners in community 2. But this cannot happen generically, that is, for arbitrary income distribution functions F(.).

Proof of Result 6

For an asymmetric equilibrium with $x_1^* > x_2^*$ to violate tenure segregation, it must be that: $1 > x_1^* > x_2^* > 0$. Then there are renters in both communities, and so $\rho_1^* - \rho_2^* = q_1^* - q_2^*$. Then, Condition (**) implies that $y_1^* < y_2^*$. This implies that for $y \in (y_1^*, y_2^*]$, $u_1^*(y) > q_1^* - \rho_1^* = q_2^* - \rho_2^* = u_2^*(y)$, and that for $y > y_2^*$, $u_1^*(y) = q_1^* - \rho_1^* + \min\{C(y - y_1^*), S_1^*\} > q_2^* - \rho_2^* + \min\{C(y - y_2^*), S_2^*\} = u_2^*(y)$. This means that all households with income $y > y_1^*$ will strictly prefer to be home-owners in community 1. But this implies that there cannot be any home-owners in community 2, contradicting our original supposition.

Proof of Result 7

Let E* be an equilibrium with $x_1^* \in (0, 1]$ and $x_2^* = 0$. First consider the case where $x_1^* \in (0, 1)$. Then, following the arguments presented in Result 6, it must be that all households with income $y \geq y_1^*$ prefer to be home-owners in community 1, and all households with $y < y_1^*$ are indifferent between renting in either community. Further, $x_1^* < 1$ implies that $y_1^* > Y^m$. Then it is easy to construct an equilibrium with the same (x_1^*, x_2^*, ρ_2^*) as in E*, where $\mathbf{Y}_1^* = \mathbf{Y}^H$ and $\mathbf{Y}_2^* = \mathbf{Y}^L$. Here, all $y \in \mathbf{Y}^H$ with $y \geq y_1^*$ own in community 1, all $y \in \mathbf{Y}^H$ with $y < y_1^*$ rent in community 1, and all $y \in \mathbf{Y}^L$ rent in community 2.

Next, consider the case where $x_1^* = 1$. If $\mathbf{Y}_1 = \mathbf{Y}^H$ and $\mathbf{Y}_2 = \mathbf{Y}^L$ in E*, then there is nothing to prove. So suppose that there exists a subset $\mathbf{Y}'$ of $\mathbf{Y}^H$ such that all households with $y \in \mathbf{Y}'$ rent in community 2. Then there must exist a subset $\mathbf{Y}''$ of $\mathbf{Y}^L$ such that all households with $y \in \mathbf{Y}''$ own in community 1. Pick any household with income $y'' \in \mathbf{Y}''$. Then there must exist a household with $y' \in \mathbf{Y}'$ such that $y' > y''$. It must be the case that y'' prefers to own in community 1 rather than rent in community 2, while the opposite is true for y'. This requires: $\min\{C(y'' - y_1^*), S_1^*\} \geq \rho_1^* - q_1^* - \rho_2^* + q_2^* \geq \min\{C(y' - y_1^*), S_1^*\}$. This can be satisfied if and only if $y'' \geq \beta^*(1,\rho_1^*)$. Since our choice of y'' was arbitrary, the

above argument implies that $y \geq \beta^*(1,\rho_1^*)$ for all $y \in \mathbf{Y}''$, and thus for all $y \in \mathbf{Y}'$. Further, it must also be that $\rho_1^* - \rho_2^* = q_1^* - q_2^* + S_1^*$. This means that all households with $y \in \mathbf{Y}'$ are indifferent between renting in community 2 and owning in community 1, and the same is the case for all $y \in \mathbf{Y}''$. Then we can construct an equilibrium with the same (x_1^*, x_2^*, ρ_2^*) as in E*, where $\mathbf{Y}_1^* = \mathbf{Y}^H$ and $\mathbf{Y}_2^* = \mathbf{Y}^L$. Finally, note that if $Y^m < \beta^*(1,\rho_1^*)$, then the above described chain of inequalities cannot be satisfied, and in that case, the set $\mathbf{Y}'$ has to be empty.

Proof of Result 8

Let E* be an equilibrium with $x_1^* = 1$ and $x_2^* \in (0, 1)$. If $\mathbf{Y}_1 = \mathbf{Y}^H$ and $\mathbf{Y}_2 = \mathbf{Y}^L$ in E*, then there is nothing to prove. Since $Y^+ < \beta^*(1,\rho_1^*)$, the corollary to Result 7 asserts that no household with $y \in \mathbf{Y}^H$ will rent in community 2. So suppose that there exists a subset $\mathbf{Y}'$ of $\mathbf{Y}^H$ such that all households with $y \in \mathbf{Y}'$ own in community 2. Then there must exist a subset $\mathbf{Y}''$ of $\mathbf{Y}^L$ such that all households with $y \in \mathbf{Y}''$ own in community 1. We will argue that this will be possible if and only if the following conditions hold: $y_1^* < y_2^*$; $y_2^* \leq y < \beta_2^*$ for all $y \in \mathbf{Y}''$; and $\rho_1^* - \rho_2^* = q_1^* - q_2^* + C[y_2^* - y_1^*]$. When these conditions hold (and given that $Y^+ < \beta^*(1,\rho_1^*)$), it is easy to prove that all households with $y \in \mathbf{Y}''$ are indifferent between owning in either community, as are all households with $y \in \mathbf{Y}'$. Then we can construct an equilibrium with the same (x_1^*, x_2^*, ρ_2^*) as in E*, where $\mathbf{Y}_1^* = \mathbf{Y}^H$ and $\mathbf{Y}_2^* = \mathbf{Y}^L$.

We now prove the conditions stated above. Pick any household with income $y'' \in \mathbf{Y}''$ who owns in community 1. Note that if $y'' \geq \beta_2^*$, then all $y > y''$ will strictly prefer to own in community 1, implying that $\mathbf{Y}'$ is empty. So, $y'' < \beta_2^*$. Then for y'' to prefer to own in community 1 rather than in community 2, we need: $C[y_2^* - y_1^*] \geq (\rho_1^* - \rho_2^*) - (q_1^* - q_2^*) \geq 0$ (the last inequality following from the fact that there are some renters in community 2 in E*). This condition cannot be satisfied if $y_1^* > y_2^*$, or if $y_1^* = y_2^*$ (since then $\rho_1^* - \rho_2^* = q_1^* - q_2^*$ and Condition (**) requires $y_1^* < y_2^*$). This proves that $y_1^* < y_2^*$. Given that it is easy to prove that if either $y'' < y_2^*$, or if $y'' \geq y_2^*$ and y'' strictly prefers to own in community 1, then all $y \in (y'', Y^+]$ strictly prefer to own in community 1, implying that $\mathbf{Y}'$ is empty. So, as our choice of y'' was arbitrary, we conclude that $y_2^* \leq y < \beta_2^*$ for all $y \in \mathbf{Y}''$, and that $\rho_1^* - \rho_2^* = q_1^* - q_2^* + C[y_2^* - y_1^*]$.

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