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Raquel Fernandez
Richard Rogerson

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ABSTRACT

This paper examines the effects of a zoning regulation on local redistribution in a multi-community model. Each community chooses, by majority vote within the community, a property tax rate. The proceeds from this tax are then redistributed within the community on a per capita basis. Individuals that differ in their initial income choose a community in which to reside and how much housing to purchase. We examine the effects on allocations and welfare of a zoning regulation that allows one of the communities to set a minimum housing purchase for each of its residents. Two cases are analyzed: In the first, the zoning regulation is taken as exogenous. In the second, the level of zoning is endogenously determined via majority vote. Some of our findings are: (i) Contrary to results obtained in a model with no zoning, wealthy communities may engage in greater redistribution than do poorer communities. (ii) Zoning may cause the wealthy community to become less, rather than more, exclusive. (iii) Welfare effects are not monotone in income. (iv) It is possible for the wealthiest individuals to be made worse off by the imposition of zoning.

Raquel Fernandez
Department of Economics
Boston University
Boston, MA 02215
and NBER

Richard Rogerson
University of Minnesota
271 19th Avenue South
Minneapolis, MN 55455

1. Introduction

A common feature of modern economies is the existence of a variety of programs that redistribute income across members of society. Economists have long been interested in the impact of particular redistribution schemes. More recently, accompanying the renewal of interest in political economy, there have been several attempts to model the determinants of the degree of redistribution a society carries out (e.g. Meltzer and Richard (1981), Persson and Tabellini (1990), Alesina and Rodrik (1991), Fernandez and Rogerson (1991)). The analyses have almost all been carried out in the context of a single redistribution scheme in which agents' participation is mandatory and ineludible, e.g. redistribution carried out at the national level. While many redistributive programs undoubtedly are of this nature, there is also a considerable amount of redistribution that, by taking place at a lower level, is less universal in scope (e.g. redistribution at the state or local level). Naturally, if individuals are unable to change locality, this distinction among levels is basically one of terminology. If, however, individuals (or, more generally, the factors being taxed) are free to move among jurisdictions, then a system of local redistribution may behave very differently than a system of national redistribution.[1]

Several recent papers have examined various aspects of local redistribution. Wildasin (1991), for example, studies state and federal redistributive schemes in a federal system with mobile labor. Gordon (1992) examines the pressures for tax policy harmonization induced by labor mobility in the context of the US-Canada free trade agreement. Wildasin (1993) analyzes the effect of mobility on estimates of the burden associated with US

[1]See, for example, Stigler (1957), Oates (1968), and Musgrave (1969) for a discussion of this point.

state income taxes. Wilson (1986) constructs a general equilibrium model of interregional tax competition where local governments use the level of the local property tax to trade off between public expenditure and the need to compete for mobile capital.

Our work is most closely related to a recent paper Epple and Romer (1991). They analyze the limits to income redistribution at the community level in a model in which the level of redistribution is endogenously chosen by a finite number of communities and where individuals characterized by different initial income endowments can move costlessly between communities.[2] Free mobility of individuals presumably restricts the program that any one community can adopt in equilibrium, affecting the pattern of redistribution that can be found across communities. At a general level, their model has strong implications for the pattern of redistribution that can exist across communities. In equilibrium communities are stratified by income, and wealthier communities must have lower tax rates and less redistribution than less wealthy communities. They also provide examples that illustrate that free mobility of individuals does not preclude individual communities from engaging in "significant" amounts of redistribution even if some communities have zero redistribution.

Although a model with unrestricted mobility may serve as a useful benchmark, it is also somewhat extreme, since in reality there are several factors that may impact upon an individual's ease of mobility across communities. Whereas some of these factors may be technological in nature,

[2]Cassidy, Epple and Romer (1992) and Epple and Platt (1992) have used a similar model.

(e.g. it may be costly to move from one location to another), other factors may be determined by the communities themselves. One pervasive feature of this type is community zoning laws. These take a variety of forms, but in general they restrict access to a community by regulating the type of housing services that can be offered (e.g. minimum lot sizes, minimum housing sizes, prohibition of apartments or low income housing).

The contribution of this paper is to attempt to study how the presence of a particular zoning regulation affects redistribution in a multi-community setting in which (as in Epple and Romer (1991)) communities endogenously decide on the degree of income redistribution. We examine how zoning affects community composition and community allocations, as well as the welfare effects across individuals (that are heterogeneous in initial income) of the imposition of such regulations.

The analysis is carried out in a simple setting. We assume the existence of two communities, which one may think of as a central city and a suburb. The suburb is allowed to have a rule that requires all its residents to consume housing services greater than or equal to some specified level. Two cases are considered. In the first case, the zoning regulation is given exogenously, perhaps as a result of decisions made in the past. In the second case, the zoning regulation is determined endogenously through a process of majority vote. Additionally, each community levies a tax on property and uses the proceeds to provide each resident with a lump sum grant. The property tax rate in each community is also chosen by majority vote.

Several results are obtained. First, we show that in any equilibrium in which the two communities differ, individuals will be stratified by income;

higher income individuals live in the suburbs and lower income individuals live in the central city. Second, and in contrast to the results obtained by Epple and Romer, with zoning there are no restrictions on the pattern of taxes and redistribution across communities; the wealthy community may have higher or lower taxes and engage in more or less redistribution than the poorer community. Third, and somewhat surprisingly, whether zoning induces the wealthy community to become more or less exclusive depends on the level of required housing purchases. Welfare effects are also non-trivial. Whereas one might expect zoning laws to benefit wealthy individuals at the expense of poorer individuals, we find that welfare effects are not monotonic in income. In some cases we even find that the imposition of zoning benefits poorer individuals at the expense of wealthier ones. This possibility results from the effect of zoning on the endogenously chosen tax rates and levels of redistribution. Finally, our examples show that the level of zoning that results from majority voting need not coincide with that preferred by the individual with median income in the community.

Although there is an extensive literature which addresses various facets of zoning, and a growing literature on multi-community models, the literature on zoning in the context of multi-community models is quite small.[3] In one class of models, Durlauf (1992), Fernandez and Rogerson (1993), and Hamilton (1975) analyze equilibrium in multi-community models with zoning where communities implicity redistribute income by endogenously determining the level of public provision of some good, such as education. Epple, Romer, and

[3]See Pagodzinski and Sass (1990,1991) and Mills and Oates (1975) for reviews of the zoning literature. Westhoff (1977) and Rose-Ackerman (1979,1983) are early contributions to the multi-community literature.

Filimon (1988) and Henderson (1980) also study zoning in a multi-community setting but focus on a very different issue. They analyze how initial residents of communities affect future patterns of land use via zoning regulations and do not consider redistributive programs.[4]

The outline of the paper is as follows. The next section describes and analyzes a benchmark model in which there is redistribution but no zoning. Section 3 introduces exogenous zoning restrictions into the model and examines the model analytically. In order to further illustrate the workings of the model with exogenous zoning, section 4 provides results obtained from simulations. Section 5 studies a model in which zoning is determined endogenously and section 6 concludes.

2. The Model Without Zoning

There is a continuum of individuals, with total mass equal to one, each with identical preferences given by the utility function $u(c,h)$, where h is housing and c is consumption of a private good. It is assumed that u is strictly concave, twice continuously differentiable, and that preferences are homothetic.[5] Individuals differ in their endowment of income, y, which is distributed on the interval $[\underline{y},\bar{y}]$ with cdf $F(y)$ and density $f(y)$.

Individuals can live in one of two communities, denoted by C_j, $j=1,2$. Each community j is characterized by a proportional tax t_j on housing

[4]Benabou (1992) studies the efficiency consequences of peer effects in a two-community model in which each community can accomodate a fixed number of households. In his model, however, individuals are ex ante identical and there is no redistribution.

[5]Note that homotheticity implies that both goods are normal. Homotheticity is stronger than what is needed for most results (i.e. normality suffices), but it is useful in the proof of Proposition 1.

expenditures, a lump-sum grant g_j to each of its residents and a net-of-tax housing price p_j. Each community has its own housing market, with supply of housing in C_j given by $H_j^S(p_j)$. Note that this function is allowed to differ across communities, reflecting differences in land endowments and other factors. We assume that H_j^S is increasing, continuous, and equal to zero when p is zero. The gross-of-tax housing price in C_j is given by $\pi_j=(1+t_j)p_j$.

We assume that the interaction among individuals and communities can be described as a stage game of the following form. In the first stage, all individuals simultaneously choose a community in which to reside. Thereafter, individuals are assumed to no longer be able to move.[6] In the second stage, communities choose tax rates through a process of majority voting, after which individuals make their housing and consumption choices.

From an individual's perspective, a community is completely characterized by the pair (π,g). Thus, an individual with income y has an indirect utility function $V(\pi,g;y)$ defined by:

$$V(\pi,g;y) = \max_{c,h} u(c,h) \quad \text{s.t.} \quad \pi h+c\le y+g,\ c\ge 0,\ h\ge 0, \tag{1}$$

where c has been chosen as numeraire. Define $h(\pi,y+g)$ to be the individual housing demand resulting from this problem. It is straightforward to show that normality of h implies that the slope of an indifference curve in (π,g) space is increasing in a person's income (see Epple and Romer (1991)). It follows that if $(\pi_a,g_a)<<(\pi_b,g_b)$ and an individual with income $\tilde{y}$ prefers

[6]This assumption, while not entirely realistic, allows each individual to take the composition of the community as given when voting. This greatly simplifies the strategic interactions between communities.

(π_a, g_a) then so do all individuals with $y > \tilde{y}$. Similarly, if an individual with income $\tilde{y}$ prefers (π_b, g_b), then so do all individuals with $y < \tilde{y}$.

Given a set of residents and a tax rate t_j in C_j, g_j and p_j must satisfy:

$$\int_j h(\pi_j, y+g_j) = H_j^s(p_j) \tag{2.1}$$

$$t_j p_j \int_j h(\pi_j, y+g_j) = g_j N_j \tag{2.2}$$

where the integrals are over residents of C_j, and N_j is the mass of residents in C_j. The first equation requires that the housing market clear, and the second states the budget constraint for each community, i.e. the per person grant g_j times the mass of residents in the community equals the total tax revenue of the community.

The following proposition summarizes some useful properties of the solutions to (2.1) and (2.2) as a function of t_j.

Proposition 1: For every value of t_j, equations (2.1) and (2.2) have unique solutions $g_j(t_j)$ and $p_j(t_j)$. Moreover, $\pi_j(t_j)=(1+t_j)p_j(t_j)$ is increasing in t_j, and $p_j(t_j)$ is decreasing in t_j.

Proof: Using the fact that $H_j^s(0)=0$ and that g_j is bounded from above, it is straightforward to show that for every value of t there is at least one solution to (2.1) and (2.1). Next we prove uniqueness. Suppose that for some $t_j=t$ there are two solutions to the system of equations given by (2), denoted by (p', g') and (p'', g''). First note that $p' >(<) p''$ if and only if $g' >(<) g''$, since the right-hand side of (2.1) is increasing in p_j and the left-hand side is increasing in g_j and decreasing in p_j for a given t. Let, therefore,

$(p',g')>>(p'',g'')$. Aggregating over all individual budget constraints in C_j yields:

$$Z_j + p_j H_j = N_j \mu_j, \qquad (3)$$

where Z_j is community consumption of the private consumption good, H_j is community consumption of housing, and μ_j is community mean income. But, from equilibrium in the housing market and the housing supply function we have $H_j(p')>H_j(p'')$, and homotheticity implies $c'/h'>c''/h''$, where (c',h') and (c'',h'') are the utility maximizing choices for an individual facing (p',g') and (p'',g'') respectively. Furthermore, by homotheticity the ratio of c to h is independent of y and g, and thus, in addition we must have $Z_j'>Z_j''$. The left-hand side of (3) must therefore be greater when evaluated at (p',g') than when evaluated at (p'',g''), whereas the right-hand side is independent of (p,g). Thus (3) cannot hold for both (p',g') and (p'',g'').

We now argue that p is decreasing in t and that π is increasing in t. Consider an increase in t. At a constant p, π must also increase and, by homotheticity, so must c/h. Since at a constant p, H_j is constant, this implies that Z_j must increase. Thus, for p constant (or increasing) the left-hand side of (3) is increasing in t whereas the right-hand side is constant. Thus p must decrease. A similar argument establishes that π is increasing in t. Were it to decrease, then c/h must fall, but given that p decreases, H_j must also and thus Z_j falls. The lower values of the variables on the left-hand side (resulting from π constant or decreasing) do not satisfy (3). Thus π is an increasing function of t.||

We solve for the subgame perfect equilibria of the game. Note that for any equilibrium outcome (π_j^*, g_j^*), each individual resides in the community that yields her the greater utility. To ensure that in equilibrium we do not end up with a community with no residents, we assume that for any strictly positive value of c, u(c,h) is unbounded as a function of h. From this we obtain:

Lemma 1: In equilibrium no community is empty.

Proof: $H_j^S(0)=0$ implies that an empty community has price of housing equal to zero, and hence offers infinite utility to anyone who chooses to reside there.||

The following two propositions characterize some features that a subgame-perfect equilibrium in this model must possess.

Proposition 2: Given a set of residents, majority voting over tax rates in a community results in the preferred tax rate of the resident with the median income.

Proof: This follows immediately from the property of indifference curves discussed previously. See Epple and Romer (1991) and Fernandez and Rogerson (1993) for detailed proofs in slightly different contexts.||

Proposition 3: If in equilibrium π_1^* is not equal to π_2^*, then:

(i) $(\pi_1^*, g_1^*) << (\pi_2^*, g_2^*)$

(ii) All individuals in C_1 have income at least as great as all individuals in C_2

(iii) $p_1^* > p_2^*$

where C_1 is defined as the community with the lower value of π.

Proof: (i) If $\pi_1^* < \pi_2^*$ and $g_1^* \geq g_2^*$ then everyone prefers to live in C_1. But, by Lemma 1, we know that in equilibrium no community is empty.

(ii) Follows directly from property of indifference curves in (π, g) space as a function of y.

(iii) Suppose not. Then any individual whose housing consumption is greater than the average in C_2 could be made strictly better off by moving to C_1 since in C_2 she is implicitly transferring income to others and paying higher prices for housing. More formally, assume that $(\pi_1^*, g_1^*, p_1^*) << (\pi_2^*, g_2^*, p_2^*)$ and that an individual with income y_b^* is indifferent between residing in the two communities. (Note that if no community is empty then such an individual must exist.) Let (c_j, h_j) be the individual's allocation when residing in C_j. It follows from homotheticity and indifference between the two communities that $h_1 > h_2$ and $c_1 < c_2$. Moreover, if $\bar{h}_j$ is per capita housing in C_j then $\bar{h}_1 > h_1 > h_2 > \bar{h}_2$. Note that an individual's budget constraint can be written as:

$$y + t_j p_j (\bar{h}_j - h_j) = p_j h_j + c_j. \tag{4}$$

It follows that if the individual with income y_b^* were to choose (c_2, h_2) in C_1 (note that this is feasible since $\bar{h}_1 > h_2 > \bar{h}_2$ and $p_1 < p_2$), then she would have strictly positive income left over. Thus, this individual must prefer to reside in C_1, which contradicts the assumption of indifference between C_1 and C_2.||

Proposition 3 implies an equilibrium with $\pi_1^* \neq \pi_2^*$ will be characterized by the coexistence of a community with high income residents, high housing prices, low property taxes, and small redistribution (i.e. low g) and another community with lower income residents, low housing prices, high property taxes and a larger degree of redistribution.

Any equilibrium that displays property (ii) of Proposition 3 is said to be a stratified equilibrium. This type of equilibrium is common to multi-community models, most often as a result of imposing single crossing conditions on indifference curves (e.g. Westhoff (1977), Fernandez and

Rogerson (1992, 1993)). In this model, this property follows naturally from the normality of housing (see also Epple and Romer (1991)). It should also be noted that with the assumptions imposed equilibrium need not exist, and if it exists it may not be unique. This is a problem endemic to multi-community models (see, for example, Westhoff (1977,1979) and Epple, Filimon and Romer (1984) for a discussion). In all of the simulations reported later in the paper we choose specifications for which a unique equilibrium exists.[7]

Stratified equilibria can be parametrized by the income level of the poorest individual in C_1, or equivalently, the richest individual in C_2. We denote this level of income as y_b, and refer to any individual with income y_b as the boundary individual. Each value of y_b can be used to determine the residents of the two communities since it partitions the income space into higher income individuals that reside in C_1 and lower income individuals that reside in C_2. Define $W_j(y_b)$ to be the utility of an individual with income y_b residing in C_j given that y_b is used to determine the residents of the two communities and that each community chooses its tax rate via majority voting. An equilibrium can be depicted as an intersection of the two W_j curves for which $(\pi_1,g_1)<<(\pi_2,g_2)$ (see Figure 1).

We now examine the W_j curves in greater detail. The community subscript is suppressed to economize on notation. Let $g(t,y_b)$ and $p(t,y_b)$ be the solutions to equations (2.1) and (2.2) when y_b is used to partition residents of the two communities. Let $\pi(t,y_b)$ be the resulting gross price of housing. By inspection of equation (3), $p(t,y_b)$ is increasing in y_b in C_2 and

[7] We also ignore equilibria in which communities are identical, i.e. characterized by $\pi_1=\pi_2$ and hence by $g_1=g_2$.

decreasing in C_1 since total community income is increasing in the former and decreasing in the latter. The effect of an increase in y_b on g is ambiguous, however, since total tax revenues and population size move in the same direction.

Given y_b, the preferred tax rate of an individual with income y is determined by:

$$\max_{t\geq 0} V(\pi(t,y_b),g(t,y_b);y) \qquad (5)$$

Using the envelope theorem, the first order condition for this problem implies:

$$K(t,y_b,y) = g_t-\pi_t h = 0 \qquad (6)$$

where h and c are the utility maximizing choices for an individual with income y and the t subscript denotes the partial derivative of the variable with respect to t. Condition (6) has a natural interpretation: it states that at an optimum the marginal increase in the grant from the higher rate of taxation should exactly offset the increase in the cost of housing. The second order condition requires $K_t(t,y_b,y)\leq 0$.

It is straightforward to show that Proposition 1, normality of h and the second order condition imply that (for a given y_b) an individual's preferred tax rate is a decreasing function of her income. Hence, holding community composition fixed, higher-income individuals prefer less redistribution than do lower-income individuals.

Let $t(y_b)$ be the tax rate chosen by majority vote given that y_b is the boundary individual, i.e. $t(y_b)$ is the preferred tax rate of the individual with median income in the community. Let $\hat{y}$ denote the level of median income in the community. In order to be able to further characterize the W_j curves we need to be able to say how changes in y_b affect the W_j curves. Straightforward calculation yields:

$$\frac{dW}{dy_b} = u_1(c,h)[1+(g_t-\pi_t h)dt/dy_b + \partial g/\partial y_b], \qquad (7)$$

where c and h are the utility maximizing choices for an individual with income y_b. Although this expression cannot be signed unambiguously, it is instructive to consider each of the terms in the square brackets. The term $g_t-\pi_t h$ is decreasing in y and equals zero when $y=\hat{y}$, so it is positive in C_1 (where $y_b<\hat{y}$) and negative in C_2 (where $y_b>\hat{y}$) reflecting the fact that relative to the individual with median income, the richest individual prefers lower taxes whereas the poorest individual prefers higher taxes.

The change in the tax rate that results from a change in y_b is given by:

$$\frac{dt}{dy_b} = \frac{-[\frac{\partial K}{\partial y_b}\frac{d\hat{y}}{dy_b} + \frac{\partial K}{\partial y_b}]}{\frac{\partial K}{\partial t}} \qquad (8)$$

where K is evaluated at $y=\hat{y}$. The denominator is negative by the second order condition, $\partial K/\partial y$ is negative since π is increasing in t and h is a normal good, and $d\hat{y}/dy_b$ is positive. The final term, $\partial K/\partial y_b$, is more complicated. In both communities g_t is increasing in y_b, but the change in π_t may be positive or negative and, if negative, it may dominate the change in g_t. Note that if $\partial K/\partial y_b$ is positive, then the change in the tax rate resulting from a marginal increase in y_b is ambiguous.

Finally, $\partial g/\partial y_b$ is given by:

$$\frac{\partial g}{\partial y_b} = \frac{pt\frac{\partial \bar{h}}{\partial y_b} + t\frac{\partial p}{\partial y_b}(\bar{h}+\pi\frac{\partial \bar{h}}{\partial \pi})}{1-tp\frac{\partial \bar{h}}{\partial g}} \qquad (9)$$

Normality of c and normality of h respectively imply that the denominator and the first term in the numerator are positive. Using the property of homothetic functions we can rewrite $h(\pi,y+g)$ as $r(\pi)(y+g)$ (with $r'(\pi)<0$), thus $\bar{h}=r(\pi)(\mu+g)$ and equation (9) can be rewritten as:

$$\frac{\partial g}{\partial y_b} = \frac{ptr\frac{\partial \mu}{\partial y_b} + \frac{\partial p}{\partial y_b}t(\mu+g)(r+\pi r')}{1-tpr}, \qquad (10)$$

where μ denotes mean income in the community. The second term in the numerator is ambiguous in sign. It is, however, easily interpretable. Holding t constant, p increases with community population, so $\partial p/\partial y_b$ is positive in C_2 and negative in C_1. The sign of $r+r'\pi$ depends on whether the demand for housing is elastic or inelastic.

To summarize, as y_b changes there are three factors that influence the utility of the boundary individual. First, the income of the boundary individual increases, thereby increasing utility. Second, the tax rate changes, but the sign of the change is ambiguous. An increase in the tax rate will cause y_b's utility to increase in C_1 and decrease in C_2. Third is the change in utility associated with the change in g holding the tax rate constant. With p constant, this third effect always results in higher utility, since g increases with an increase in average housing (given that t is held constant). Thus, in theory it is possible for the W_j curves to be upward or downward sloping. In all of the simulations performed later in the paper, both W_j curves were always found to be upward sloping.

3. The Model With Exogenous Zoning

In the previous section a stratified equilibrium was characterized by the coexistence of a wealthy community and a poor community. A prominent feature of many wealthy communities is the existence of zoning laws which make it difficult for poorer individuals to reside there. These regulations clearly may have significant implications for the pattern of redistribution that is observed across communities. In this section we analyze the effects of exogenously imposed zoning laws in the rich community, where these zoning laws take the form of a requirement that each resident purchase at least M units of housing. In a later section we consider a model in which the size of the purchase requirement is determined endogenously. There are two reasons for considering the case of exogenously imposed zoning regulations. First, once a particular set of zoning regulations have been put in place, and lot sizes determined and housing constructed, it can be difficult to reverse these decisions, so that existing zoning regulations may largely be inherited from past decisions. Second, the analysis of the effects of exogenous zoning in greatly facilitates the analysis of endogenous zoning.

The model in this section is identical to that in the previous section in all regards, except for zoning. Hence, all functions now contain M as an argument, with the understanding that $M=0$ in C_2. Equations (2.1) and (2.2) are accordingly modified in the case of community 1. Given (π, g, M) an individual's problem is now:

$$\max_{c,h} \; u(c,h) \text{ s.t. } c+\pi h \leq y+g, \; h \geq \underline{M}, \; c \geq 0 \qquad (11)$$

where $\underline{M}$ is defined as $\min(M, (y+g)/\pi)$.

It is implicitly assumed that an individual who resides in C_1 and who cannot afford to purchase M units of housing is required to spend all of her income on housing. To ensure that under such circumstances an individual would always prefer C_2 over C_1, we assume:

$$u(0,h) < u(c,h') \; \forall \; (h,h'), \; c>0. \qquad (12)$$

The next proposition establishes that the introduction of zoning as described above does not alter the stratification result in Proposition 3 if we assume in addition that $u_{12} \geq 0$.

<u>Proposition 4</u>: If $\pi_1^* < \pi_2^*$, then all individuals in C_1 have income at least as great as all individuals in C_2.

<u>Proof</u>: First note that, by (12), any individual with an income level such that $y+g_1<\pi_1 M$ strictly prefers C_2 over C_1. Next, define $D(y)=V(\pi_1,g_1,M;y)-V(\pi_2,g_2,0;y)$ for y such that $y+g_1>\pi_1 M$. Differentiation yields:

$$dD/dy = u_1(c_1,h_1) - u_1(c_2,h_2), \qquad (13)$$

where h_j and c_j are the choices for an individual with income y in C_j. Note that this expression holds independently of whether $h_1=M$ or $h_1>M$. Suppose $D(y)=0$ for some y denoted by $\tilde{y}$. Then, either $h_1 \geq h_2$ and $c_1 \leq c_2$ or $h_1<h_2$ and $c_1>c_2$. Homotheticity of preferences and $\pi_1<\pi_2$ implies that the first case must hold. Then strict concavity of u and $u_{12} \geq 0$ imply that $dD/dy>0$ at $\tilde{y}$. From continuity of V it follows that $D(\tilde{y})=0$ and $D'(\tilde{y})>0$ imply that $D(y)>0$ for all $y>\tilde{y}$, which proves the proposition.||

The above result establishes that if $\pi_1^* < \pi_2^*$ then the equilibrium will be stratified. Note that this result places no restrictions on the relative sizes of g_1^* and g_2^*. If $\pi_1^* < \pi_2^*$ and $g_1^* \geq g_2^*$ then everyone would prefer to live in C_1 in the absence of a minimum required housing purchase. The zoning regulation, however, allows both communities to coexist in equilibrium. Furthermore, as simulations performed later in the paper illustrate, the introduction of zoning implies that a stratified equilibrium in which $(\pi_1^*, g_1^*) >> (\pi_2^*, g_2^*)$ and the wealthier individuals live in C_1 is feasible. It also would be the case in this instance that all individuals would prefer C_1 in the absence of the zoning regulation.

As in the previous section, majority voting over tax rates in C_2 results in the tax rate preferred by the median voter there since the preferences of individuals over rates remain unchanged at each y_b. The next result, which characterizes preferences over tax rates in the presence of a zoning constraint, is useful in determining the outcome of majority voting over tax rates in C_1. First, note that in the presence of zoning the first order condition for an individual's preferred tax rate holding community composition constant is still given by equation (6), but with M affecting the form of g_t, π_t and h.

<u>Proposition 5</u>: Majority voting over tax rates in C_1 results in a tax rate for which the median income individual is at a local maximum.

<u>Proof</u>: Differentiation of the indirect utility function yields:

$$\frac{dV}{dt}(\pi(t,y_b,M),g(t,y_b,M),M;y) = u_1(c,h)[g_t - \pi_t h] \qquad \text{for } y+g \geq \pi M \qquad (14)$$

$$\frac{dV}{dt}(\pi(t,y_b,M),g(t,y_b,M),M;y) = u_2(0,h)[g_t - \pi_t h]/\pi \qquad \text{for } y+g < \pi M \qquad (15)$$

where c,h are the choices for an individual with income y that solve (11). Assume first that $\pi_t \geq 0$. Consider a tax rate t'. If at this tax rate dV/dt>0 for $y=\hat{y}$, then, it follows from normality of h that it is also positive for all $y \leq \hat{y}$. Hence, all individuals with $y \leq \hat{y}$ would strictly prefer a tax rate slightly higher than t'. Similarly, if dV/dt<0, then all individuals with $y \geq \hat{y}$ strictly prefer a slightly lower tax. Thus, if a tax rate is to be a majority voting equilibrium, a necessary condition is that it satisfy dV/dt=0 for $y=\hat{y}$. A similar argument yields the same result for the alternative assumption of $\pi_t<0$.||

Proposition 5 implies that if the individual with median income has single peaked preferences over tax rates her preferred tax rate is the outcome of majority voting. Unfortunately, preferences over tax rates need not be single peaked (in simulation results reported later there are several cases in which preferences are double peaked). In the case of double peaked preferences Proposition 5 implies that there are only two candidates for the majority voting equilibrium (if it exists). In all of our simulations it turns out that majority voting results in the tax rate preferred by the individual with median income. In the analytical work that follows we assume that a majority voting equilibrium exists and that the median voter's preferred tax rate is chosen.

Next we analyze the welfare effects of changes in M for a given value of y_b. $W_j(y_b,M)$ is defined analogously to $W_j(y_b)$ except for the addition of the minimum housing expenditure in C_1. Straightforward calculation gives the effect of a change in M on an individual's utility given that the tax rate is determined by the median voter:

$$\partial V/\partial M = (u_2-\pi u_1) + u_1 g_m + u_1[g_t-\pi_t h]\partial t/\partial M \qquad \text{for } y+g\geq\pi M \qquad (16)$$

and

$$\partial V/\partial M = u_2 g_m/\pi + (u_2/\pi)[g_t-\pi_t h]\partial t/\partial M \qquad \text{for } y+g<\pi M \qquad (17)$$

The first term in (16) is zero if the individual is not constrained in her housing choice (i.e. $h>M$) and negative if she is constrained (i.e. $h=M$). The factor g_m is positive: an increase in M holding t constant increases tax revenue, since it increases both average housing purchases and the price of housing. The final term in (16) and (17) has two parts: the expression in square brackets is necessarily zero for the individual with median income. Its sign for all other individuals depends on whether π_t is negative or positive and is the same for all individuals with $y<\hat{y}$ and the same and opposite for all individuals with $y>\hat{y}$. (If the median voter is constrained, i.e. has $h=M$ then this expression is zero for all constrained individuals (with $y+g>\pi M$)).

Of particular interest is the effect of a change in M on the utility of the boundary individual since this is what determines the effect of an M increase on the W_1. Although this effect cannot be unambiguously signed, several points should be noted. First, the term $(u_2-\pi u_1)$ is negative for any constrained individual and zero for any unconstrained individual, whereas the second term $u_1 g_m$ is positive for all individuals. If the median individual is constrained then $g_t-\pi_t h$ is zero for the median individual and the boundary individual. If the median individual is not constrained and π_t is positive then the third term has the same sign as $\partial t/\partial M$.

Lastly, we need to evaluate how changes in M affect t. Recalling the definition of K given by (6) (and appropriately modified to include M), we have:

$$\partial t/\partial M = -K_m/K_t, \tag{18}$$

where $K_t<0$ by the second order condition. The numerator is equal to:

$$K_m = g_{tm}-\pi_t h_y g_m - \pi_{tm}h \text{ if } h>M,$$

and (19)

$$K_m = g_{tm} - \pi_t - \pi_{tm}m \quad \text{if } h=M.$$

Although g_{tm} and g_m can be shown to be positive, π_{tm} and hence $\partial t/\partial M$ are ambiguous. In the case where p is constant, things simplify somewhat, resulting in

$$K_m = g_{tm} - ph_y g_m \text{ if } h>M,$$

and (20)

$$K_m= g_{tm} - p \qquad \text{if } h=M.$$

It is straightforward to show that $h_y g_m$ is less than one, so that it is more likely that $\partial t/\partial M$ is negative once the median voter is constrained.

4. Simulation Results for the Exogenous Zoning Model

The theoretical analysis of the previous section indicates that there are a number of factors at play that determine the impact of zoning on equilibrium allocations and welfare. To illustrate some of the possible outcomes, this section reports results from some simulations of the model. In these simulations both W_j curves are always upward sloping and there is a unique equilibrium.

Three elements need to be specified for the simulations: preferences, the distribution of income, and housing supply functions. We assume Cobb-Douglass preferences over consumption and housing: $u(c,h) = \log c + B\log h$, with $B=.5$, implying that an (unconstrained) individual would spend one-third of her income on housing. We assume that individual incomes range from \$10,000 to \$200,000, and normalize a unit of income to be \$10,000 so that income is distributed over the interval [1,20]. The density function f for the income distribution is assumed to be linear with negative slope, and satisfies $f(20)=0$. We assume that the housing supply functions are of constant elasticity, given by:

$$\log p_j = \phi_j + \gamma \log H_j^s, \ \gamma \geq 0, \ \phi_1 = -.092, \ \phi_2 = -.000001.$$

Although the results reported below are only intended to illustrate the workings of the model, we note that there is nothing perverse about the specification just described.

We report results for two specifications, which are identical except for the value of γ, the price elasticity of housing supply. In the first simulation (Example 1) γ is set equal to .01, and in the second (Example 2) it is set equal to 0, with $p_1=1.09$, $p_2=1$. In the second case, therefore, the price of housing remains constant (since the analytical results are less complicated if p is constant, it is convenient to study this case). As will be seen, however, the results of the two simulations are similar.

Table 1 indicates how the equilibrium allocations change as M is increased. Since the patterns are very similar in the two cases, we focus on the case where the housing price is variable, reported in the top panel of the table.[8]

A few patterns stand out with respect to the effects of zoning on community allocations. First, the value of y_b^* (the equilibrium value of y_b) is not monotone in M. For the lowest values of M able to affect the equilibrium, increases in M first increase the size of the wealthy community. Further increases in M, however, reverse this pattern causing the wealthy community to become more exclusive. Tax rates, transfers, and the gross price of housing in community one all move in unison with y_b^*; i.e. they increase if y_b^* decreases and decrease if y_b^* increases. Moreover, the individual with median income ($\hat{y}$) is unconstrained by M at those equilibria for which y_b^* is decreasing in M and is constrained by M at those equilibria for which y_b^* is increasing in M (this is indicated by the last row of each example in Table 1).

To understand the effect of M on the allocations in C_1 it is instructive to examine the choices made by a given median voter as a function of M. Figure 2 plots the preferred tax rate of the median income individual as a

[8]One difference between the two examples is that tax rates and grants tend to be larger in the case where housing prices are variable. This is explained by the relationship between the elasticity of housing supply and extent to which the tax incidence is shifted to the suppliers of housing. If the housing supply function is not perfectly elastic part of the burden of the property tax is borne by the suppliers of housing, thereby creating an incentive for the demanders of housing to prefer higher tax rates.

function of M for the parameters of Example 1 given a constant y_b (y_b=14.96, i.e. the value that corresponds to y_b^* at M=0). Also shown are the associated values of g_1, p_1 and π_1. Figure 2 illustrates that t_1 first increases continuously, then jumps (discontinuously) to a higher level and then decreases continuously. Both π_1 and g_1 follow the same pattern, whereas p_1 follows the opposite pattern, decreasing continuously, then jumping (discontinuously) to a lower level and increasing continuously thereafter.

What gives rise to the discontinuity? To explain this, Figure 3 depicts $V(\pi(t,y_b,M),g(t,y_b,M),M;\hat{y})$ as a function of t for several values of M. As is easily seen, the indirect utility function is double peaked for several values of M. At the first peak the median individual has h>M, whereas at the second peak she has h=M. For lower values of M the maximum occurs at the first peak. This peak moves to the right as M increases. Further increases in M lead the median voter to choose the second peak.

Technically, the existence of two peaks is due to a non-convexity that arises as a result of the introduction of zoning. At the tax rate at which the y_b individual is first constrained, further increases in t decrease housing demand by less than what it would in the absence of zoning. Figure 4 plots the median income individual's housing purchases, h, and g_t/π_t for M=0 and M=4.7. (Recall that the first order condition for the preferred tax rate of an individual is given by $g_t-\pi_t h=0$.) In the M=0 case, both h and g_t/π_t are decreasing functions of t, but g_t/π_t is steeper than h, resulting in a unique intersection. In the case where M=4.7 both h and g_t/π_t are affected. First, h cannot drop below 4.7. Second, because of the zoning constraint, g_t/π_t does not decline as quickly as previous as t increases.[9]

The information in Figure 2 helps explain why y_b^* first decreases and then increases in M. As noted in section 3, when the median individual is unconstrained, W_1 may increase if t is increasing in M. That is, even though the y_b individual's housing demand is constrained, the fact that her housing consumption is below average means that increases in t can increase her net grant. This can make her better off. Larger tax rates and gross prices of housing will eventually make y_b worse off, thus decreasing the equilibrium value of the latter. Note that in community two zoning affects allocations solely through its effect on y_b^*. In these simulations t_2, g_2, and π_2 are all increasing functions of y_b.

Next we consider the welfare effects of changes in M. Figure 5 indicates, for three values of M, those individuals whose utility increases relative to the M=0 case. A distinguishing feature of the three cases is that relative to the M=0 case, M=4.7 results in a lower value of y_b^* whereas M=5 and M=6 result in higher values of y_b^*. This difference has significant implications for the pattern of welfare effects: the pictures for M=4.7 and M=6 are very nearly exactly opposite.

The welfare results illustrate some rather surprising outcomes. A priori, one might have conjectured that zoning will benefit wealthy residents of C_1 at the expense of its poorer residents. In the M=4.7 case, however, the outcome is exactly the reverse: it is the poor who benefit and the rich who

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[9]Note that the bottom panel of Figure 3 shows three points of intersection. Two are local maxima and one (the second one) is a local minimum.

suffer relative to the M=0 case. Moreover, all individuals in C_1 who are constrained prefer to have the zoning regulation in place. Similar results occur even if the zoning regulation has the effect of making the wealthy community more exclusive. In the M=5 case, it is the middle income individuals who gain at the expense of the poorest and richest individuals in the community. The key factor at work in producing these "surprising" outcomes is that changes in M lead to changes in tax rates, and changes in tax rates may yield welfare effects opposite to those caused by changes in M holding t,g and p fixed. Finally, note that when M=6 the welfare consequences are that the wealthiest benefit at the expense of the poorer individuals in C_1.

Lastly, a significant implication of zoning is that it is possible to have an equilibrium in which wealthy communities engage in more redistribution than do poorer communities. That is, for some range of values of M equilibrium can be characterized by $(t_1^*, g_1^*, \pi_1^*) >> (t_2^*, g_2^*, \pi_2^*)$. Clearly, therefore, the extent to which zoning reduces mobility can have significant implications for the amount of redistribution which a given communities can undertake in equilibrium.

5. The Model with Endogenous Zoning

The previous section treated M as an exogenous parameter and studied its effect on equilibrium. This section allows the zoning restriction to be endogenously determined and illustrates the properties of equilibrium through some examples.

The game played by communities and individuals is accordingly modified. As before, in the first stage all individuals simultaneously choose a community in which to reside, and once this choice is made, are unable to move in any subsequent stage. In the second stage, individuals in C_1 determine a level of housing, M, which must be purchased by all individuals that reside there (up to the exhaustion of all income) through a process of majority vote. In the third stage, individuals in both communities choose tax rates, also by majority vote, and individuals make their housing and consumption choices.

As before, an equilibrium can be depicted graphically as the intersection of two curves, $W_1(y_b)$ and $W_2(y_b)$, where the definition of $W_2(y_b)$ is unchanged and where $W_1(y_b)$ is now the utility obtained by an individual with income y_b when residing in community one given that M, t, g and p are determined according to the procedure outlined above. Note that Proposition 4 implies that any equilibrium in which the gross price of housing and/or the level of grants differ across communities must be stratified. Furthermore, Proposition 5 implies that if a voting equilibrium in the third stage exists, then the tax rate chosen must yield a local maximum for the individual with median income. What differentiates this model from the previous analysis is the addition of a stage in which individuals vote over the zoning level M. By backwards induction, an individual with income y has a preferred level of M defined by:

$$\max_{M} V(\pi(t(y_b,M),y_b,M),g(t(y_b,M),y_b,M),M,y) \qquad (21)$$

where the function $t(y_b,M)$ (which individuals take as given in the second stage) determines the tax rate in the third stage conditional on the level of M chosen.

Assuming that t (hence π and g) are differentiable at the preferred point, the first order condition for this problem is:

$$g_t t_M + g_M - (\pi_t t_M + \pi_M)h = 0 \qquad \text{if } h>M$$

(22)

$$u_1[g_t t_M + g_M - (\pi_t t_M + \pi_M)M - \pi] + u_2 = 0 \qquad \text{if } h=M$$

Figure 6 displays implied preferences over M for the case of Example 1 when y_b=14.96. The analysis in the previous sections has already analyzed how t, p, g, and π depend on M (see Figure 2). Several features are illustrated in Figure 6. First, preferences over M are not single peaked. Although an individual's preferred level of zoning is increasing in individual income in this example, at low levels of M higher-income individuals have utility that is decreasing in the level of M. This is a consequence of the relationship between M and tax rates. Holding tax rates constant, an individual would prefer M to be at least as large as her own housing demand. As indicated by the tax, grant and price curves in Figure 2, however, at low levels of M, increases in M imply higher tax rates, causing the utility of high income individuals to decrease. Thus, higher income individuals would prefer a lower level of M in this range. Second, Figure 6 shows why the M chosen by majority vote can be less than the level preferred by the individual with median income. In order for M^* to be a majority voting equilibrium it must win against all alternatives, and in particular it must win against nearby alternatives. This requires that at M^*, half the individuals must have indirect utility which is non-increasing in M and that half must have indirect utility which is non-decreasing in M. Looking at Figure 6, however, it is easily seen that at the median individual's preferred point, all individuals with $y<\hat{y}$ have indirect utility which is decreasing in M as do some individuals with $y>\hat{y}$. Furthermore, any M which exceeds the median individual's preferred point always has a majority of individuals who prefer a marginally smaller value of M. It follows that if a majority voting equilibrium exists here, it will result in a value of M which is less than that preferred by the individual with median income. This is in marked contrast to the result of voting over tax rates. Recall that preferences over tax rates are also generally not single peaked. Nonetheless, in that case it was shown that a majority voting equilibrium always picks a local maximum for the individual with median income.

In general, a majority voting equilibrium for M may not exist. We have computed equilibria with M chosen endogenously for Examples One and Two. Results are provided in Table 2.

A comparison of Table 2 with Table 1 indicates how the outcomes with endogenous zoning compare with those in which there is no zoning. In both cases the level of M chosen in equilibrium is such that the wealthy community becomes larger relative to the equilibrium with M=0. In Example One, the equilibrium has tax rates and redistribution larger in C_1 than in C_2, in sharp contrast to what can happen in the absence of a zoning regulation. In Example Two there is a significant increase in t_1 and g_1 relative to the no-zoning equilibrium, however it remains true that tax rates and redistribution are larger in the poorer community. In both cases the individual with median income is constrained by the housing requirement. A comparison with the M=4.7 case in Figure 4 provides information about welfare relative to the M=0 case for Example One; apparently zoning benefits lower-income individuals in C_1 at the expense of higher-income individuals.

6. Conclusion

Many redistributive programs operate at a local level. Given the pervasiveness of community zoning laws in the US, it is natural to inquire how these regulations affect the pattern of redistribution found across communities and who benefits as a result of these laws. The goal of this paper was to explore these questions in a simple setting.

We study a model with two communities in which each community endogenously determines the amount of income redistribution to undertake via a tax on housing. Individuals differ in their initial income and much choose a community in which to reside. One community, thought of as the suburb (in contrast to the poorer central city), is allowed to impose a zoning regulation that sets a minimum housing purchase required by all residents of that community. Two cases are analyzed: In one the minimum housing level is set exogenously, whereas in the other it is determined endogenously via majority vote.

Even within our relatively simple setting, the analysis indicates that there are a large number of forces at work and that they may affect equilibrium allocations in opposing directions. A general finding is that the range of equilibrium outcomes in the presence of zoning can be quite different that of a model without zoning. Whereas in the latter a wealthier community is necessarily characterized by lower tax rates and less redistribution than that possessed by a poorer community, this need no longer be the case once zoning is introduced. Zoning permits the wealthier community to engage in greater redistribution than the poorer one.

To further illustrate the effects of zoning on allocations and welfare, we carry out some numerical simulations of the model. Some interesting outcomes result. First, zoning may increase or decrease the tax rate in the wealthy community. Second, depending on the level of zoning the wealthy community can become less exclusive; more individuals (and poorer ones) end up residing there in equilibrium. Third, welfare effects are not generally monotone in income; there is no presumption that the wealthiest individuals will benefit as a result of zoning at the expense of the poorer ones. Lastly, it is possible for individuals that are directly constrained by the minimum housing purchase to benefit from the zoning regulation.

In summary, this paper has taken a first step in analyzing the effect of zoning regulations on allocations (particularly redistribution) and welfare in a multi-community model in which communities determine policies endogenously. While many factors undoubtedly have been omitted and alternative strategic interactions between communities have been ignored, the analysis at this basic level suggests that the effects of zoning are likely to be quite complex and that they may lead to some rather surprising outcomes even in a simple setting.

Table 1 Equilibrium With Exogenous M

(a) Example One α=0.01

M=	00.0000	04.7000	04.9000	05.0000	05.5000	06.0000
y_b^*	14.9600	14.8900	15.1500	15.2900	15.9900	16.7200
t_1^*	00.0287	00.1143	00.0944	00.0890	00.0565	00.0186
t_2^*	00.1356	00.1348	00.1379	00.1396	00.1478	00.1560
g_1^*	00.1562	00.4912	00.5134	00.4912	00.3343	00.1203
g_2^*	00.2748	00.2726	00.2810	00.2856	00.3080	00.3302
p_1^*	01.0851	01.0851	01.0845	01.0838	01.0812	01.0778
p_2^*	01.0063	01.0062	01.0064	01.0065	01.0068	01.0072
π_1^*	01.1163	01.2091	01.1870	01.1803	01.1418	01.0978
π_2^*	01.1427	01.1419	01.1450	01.1470	01.1557	01.1643
$\hat{y}$ const?	no	yes	yes	yes	yes	yes

(b) Example Two α=0.00

M=	00.0000	05.3500	05.4000	05.4200	05.4500	05.5000	06.0000
y_b^*	17.4600	17.4400	17.4200	17.4400	17.4700	17.5200	18.1900
t_1^*	00.0085	00.0110	00.0480	00.0470	00.0440	00.0410	00.0070
t_2^*	00.1524	00.1522	00.1520	00.1522	00.1525	00.1529	00.1586
g_1^*	00.0520	00.0666	00.2868	00.2816	00.2650	00.2480	00.0458
g_2^*	00.3290	00.3280	00.3280	00.3280	00.3290	00.3300	00.3456
π_1^*	01.1000	01.1020	01.1400	01.1400	01.1400	01.1350	01.0976
π_2^*	01.1524	01.1522	01.1520	01.1522	01.1525	01.1529	01.1586
$\hat{y}$ const?	no	no	yes	yes	yes	yes	yes

Table 2 Equilibrium With Endogenous M

	Example One	Example Two
M=	04.7100	05.4200
y_b^*	14.9200	17.4400
t_1^*	00.1145	00.0470
t_2^*	00.1360	00.1522
g_1^*	00.6042	00.2816
g_2^*	00.2751	00.3280
p_1^*	01.0850	01.0900
p_2^*	01.0063	01.0000
π_1^*	01.2092	01.1400
π_2^*	01.1432	01.1522
$\hat{y}$ const?	yes	yes

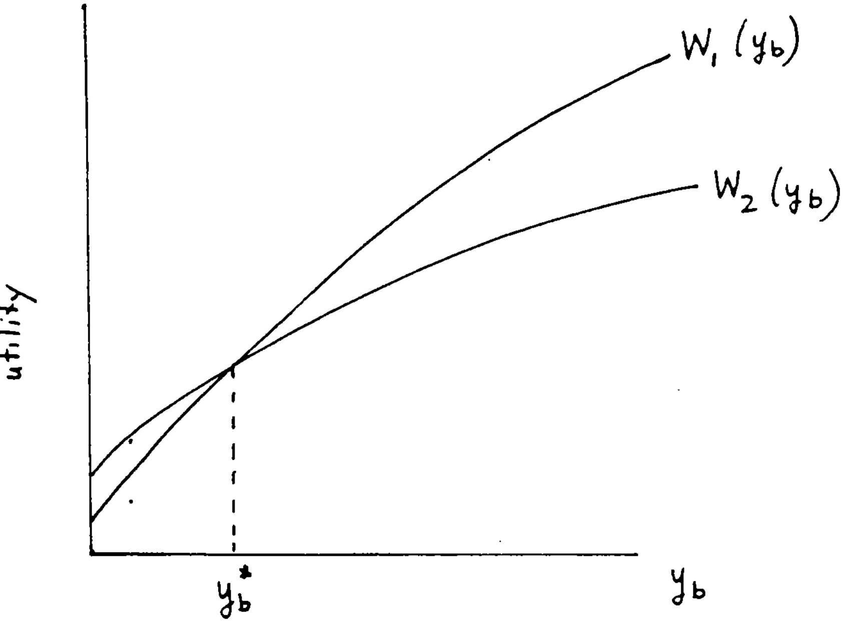


FIGURE 1

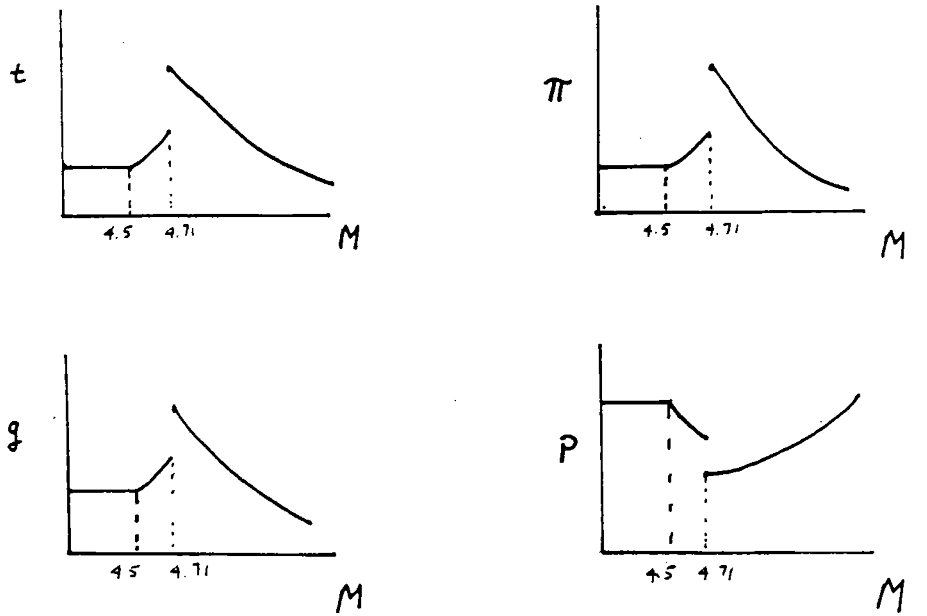
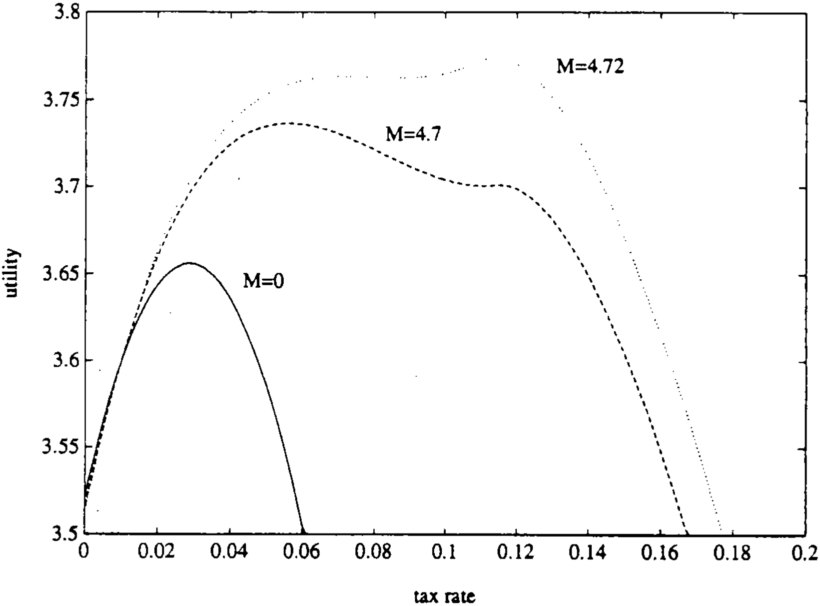


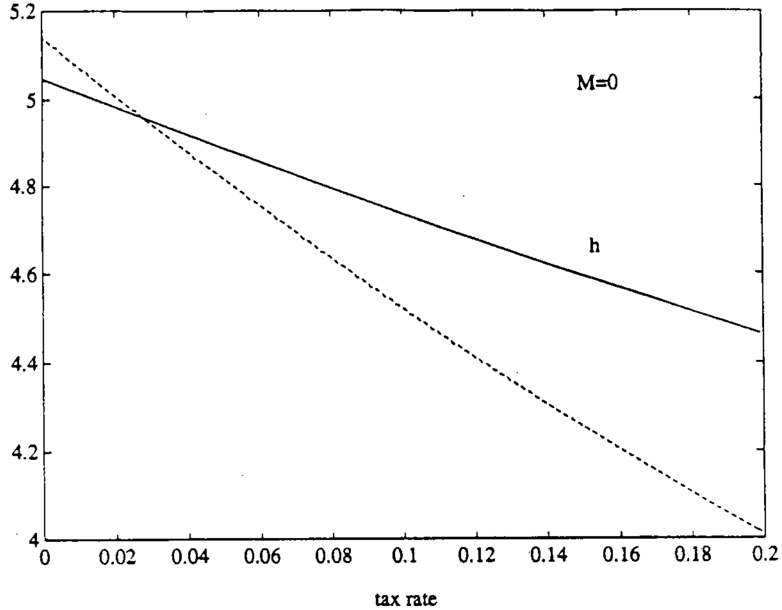
FIGURE 2



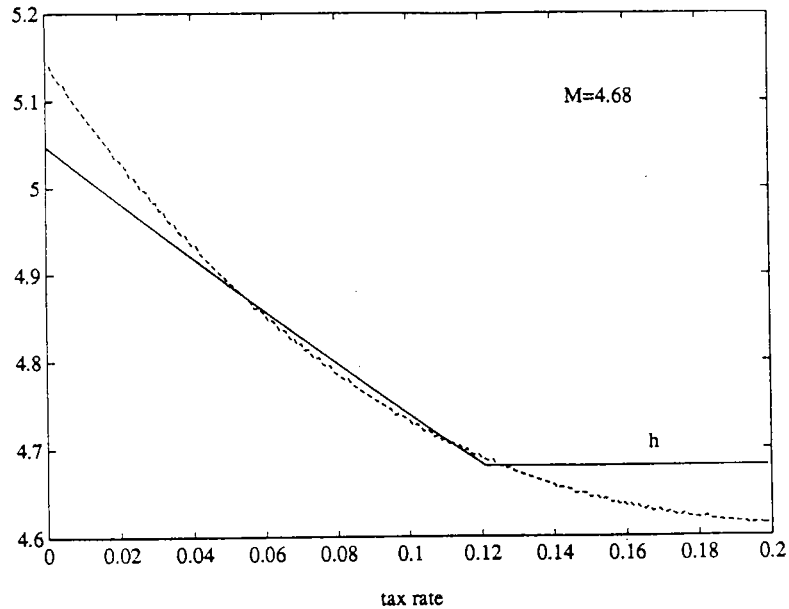
3.8
3.75
3.7
3.65
3.6
3.55
3.5
utility
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
tax rate
M=4.72
M=4.7
M=0

FIGURE 3

FIGURE 4



M=0
h
5.2
5
4.8
4.6
4.4
4.2
4
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
tax rate



M=4.68
h
5.2
5.1
5
4.9
4.8
4.7
4.6
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
tax rate

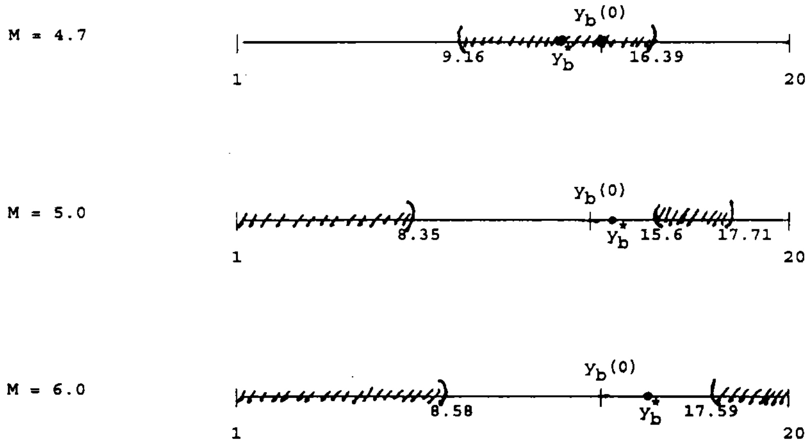


FIGURE 5

Note: Shaded area indicates individuals who prefer the given value of M to M=0. $y_b(0)$ is the equilibrium value of y_b when M=0.

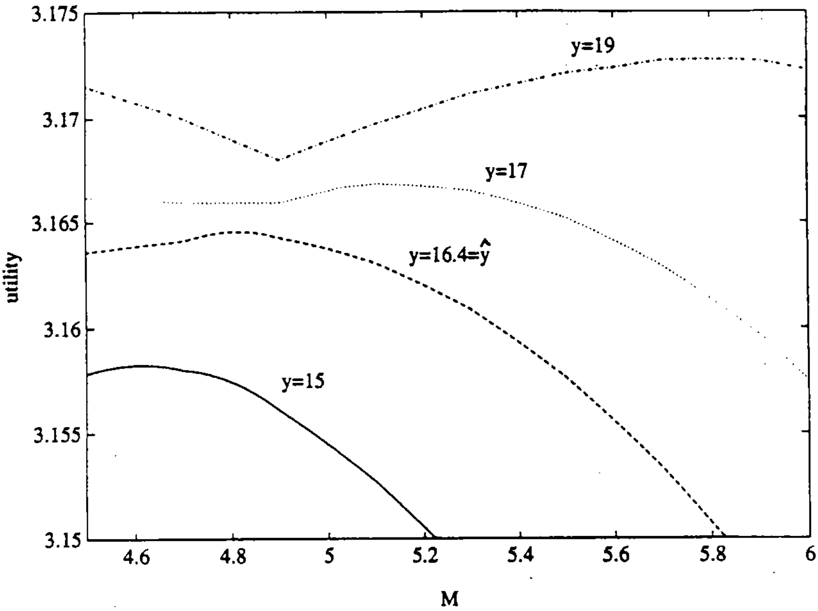

3.175
3.17
3.165
3.16
3.155
3.15
utility
y=19
y=17
y=16.4=ŷ
y=15
4.6
4.8
5
5.2
5.4
5.6
5.8
6
M

FIGURE 6

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