Urban Growth Controls under Competition and Fiscal Revenues

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Abstract

There exists numerous papers dealing with the economic consequences of fiscal competition among regions, in which local governments use taxes as a means to attract either economic activity or residents. Among the instruments most widely used at the local level are planning restrictions, or urban growth controls. The use of this type of instruments that guide local growth on the territory may have important fiscal implications, both because they alter the price of land –or the price of housing product– and because they may constitute a direct source of fiscal revenues themselves. This paper analyzes the effects of two different sorts of urban growth controls, namely urban boundaries and taxes on housing. It concentrates on how these tools compare according to their impact on the utility of residents, in a simple context in which households' utility is not affected by the consumption of local public goods.

1 Introduction

Especially from the 1980s, a great deal of literature in the urban economics field has been devoted to the analysis of territorial competition among different jurisdictions[1]. The most widely analyzed case is that of tax competition at the regional and local level. Public expenditure is usually financed in those models through a tax on capital, assumed to be mobile. Higher taxes allow for a greater –or better– provision of public goods, but they may induce the relocation of firms if cities are large enough (Wildasin, 1988).

Alternatively, local public goods could be financed through a property tax, a tax on land rents or a head tax, to name a few. Their effects may vary depending on the degree of mobility assumed for local residents. When moving across jurisdictions is free, this theory partially ressembles the Tiebout hypothesis by which residents vote "with their feet" (Tiebout, 1956).

Other type of literature has lately analyzed competition among jurisdictions from the perspective of planning restrictions. While urban regulations have mostly been understood as a means to correct externalities, a recent line of research has regarded urban planning decisions as the result of a strategic interaction process among cities. This approach allows for the emergence of restricted city sizes even though urban growth does not involve external costs [Helsley and Strange (1995), Brueckner (1998)].

Besides the welfare effects of planning regulations, though, their fiscal effects themselves of could be analyzed, too. This is the purpose of the

[1] Recent works include Brueckner (2000) and Cheshire and Gordon (1998).

paper. It is developed a framework based upon the bid-rent model (see Fujita (1989), for instance). Land rents and the size of the cities are determined, and cities compete among themselves to maximize a fiscal revenues directly associated to the use of two different types of urban growth controls. The first regulation determines the city boundary, and the second establishes a tax on housing, which indirectly affects the city size. The levels of regulations are determined as the result of a game among cities. The purpose is to compare the convenience of using one or another type from the perspective of the attained fiscal revenues.

The following of the paper goes as follows. Section 2 describes the basic model, and how land rents and the remaining key variables are determined. Section 3 deals with the consequences of urban population controls and how their levels are chosen by cities which compete among themselves. In section 4 a similar analysis is presented regarding the both the effects and the election of a tax on housing. Section 5 discusses, for an equivalent level of fiscal revenue, which type of urban planning restriction would be less harmful in terms of the negative impacts that it generates. Finally, the last section highlights the main results and suggests possible lines of future research.

2 The basic model

The benchmark model here has 3 cities, denoted by subscript i, $i = 1, 2, 3$. Cities 1 and 2 may impose growth restrictions, while in all cases city 3 simply accommodates all coming residents. Cities are supposed to be linear and with a width of 1. All residents work at the Central Business District (CBD), located at an extreme of the city. Individuals in city i must commute to the city centre at a cost $T_i(r)$, where r is the distance from the residence to the CBD. Transportation costs are the same for all cities and increase linearly with distance so that, for all i, $T_i(r) = tr$. We will abstract from differences in housing size, and assume that all households with the same income level will end up by renting housing of the same size (which will be the same across cities), and respond to utility differentials by costlessly migrating from one city to another.

All households have identical tastes, but may differ in income level. There are two levels of income: N^A individuals have an income Y^A, and N^B individuals have Y^B, with $Y^A < Y^B$. Income levels are supposed to be exogenous and the role of firms in the city is not considered. Individuals spend their income between a composite good z, taken as the numéraire; housing space s; and transportation. The utility of an individual with income Y^j ($j \in \{A, B\}$) that resides in city i ($i \in \{1,2,3\}$) is

$$u_i^j = u(s_i^j, z_i^j)$$

Housing consumption will be the same for individuals with the same income level, regardless of the city they reside in. The housing size of higher income individuals is normalized to $s_i^B = s^B = 1$; lower income individuals will have a housing size $s_i^A = s^A = \alpha$, with $0 < \alpha < 1$. Since housing space is determined exogenously, the only variables that affect the utility level achieved by households will be the consumption of all other private goods different from housing, z_i^j. Residents in each city pay housing rents to absentee landowners; the rental price of housing per period of time, which depends on the size and location of the residence, is denoted $R_i^j(r)$. The housing market is assumed to be competitive.

Given the fact that individuals have perfect mobility, in equilibrium all individuals with the same income will end up by achieving the same utility level, regardless of the city they reside in; this in turn implies that their consumption of the composite commodity, z_i^j, will be the same. Our analysis will be greatly simplified if we introduce those equilibrium conditions from the start. That is, all individuals with income level j will end up by consuming $z_i^j = z^j$, and achieving a utility level u^j. Taking this into account, the budget constraint of a household with income level j residing in city i at a distance r from the CBD can be expressed as:

$$Y^j = z^B(s^j, u^j) + s^j\, R_i^j(r) + t\, r$$

That is,

$$\begin{aligned} Y^B &= z^B(1, u^B) + R_i^B(r) + t\, r \\ Y^A &= z^A(\alpha, u^A) + \alpha R_i^A(r) + t\, r, \end{aligned}$$

In terms of the housing bid-rents, the constraints can be expressed as:

$$\begin{aligned} R_i^B(r) &= Y^B - tr - z^B \\ R_i^A(r) &= \frac{Y^A - tr - z^A}{\alpha}. \end{aligned}$$

Since transportation costs increase proportionally with distance, the housing rent or housing *bid-rent* decreases linearly with distance to the CBD. For each income level, there exists a family of housing bid-rent functions that correspond to different utility levels. For individuals to be in equilibrium and indifferent among locations within the city, housing rents must vary as described by the housing-bid rent function above. Thus, at a larger distance from the CBD, higher transportation costs are compensated by a smaller housing rent, so that all individuals belonging to the same income group can attain identical utility levels independently of the particular location. The fact that R_i^A is steeper than R_i^B implies that the low income individuals locate closer to the CBD. The segment closer to the CBD where the low income households locate has a size of $\widehat{r_i}$. High income residents locate in the outer segment comprised between $\widehat{r_i}$ and r_i, where r_i represents the edge of the city.

Housing is produced from land and capital, according to the production function $H(l,k) = lk$; given a fixed amount of land l, the (restricted) production function thus obtained displays constant returns to scale with respect to capital. Combining k units of capital and l units of land yields lk units of housing. The rental price of capital is denoted by P. It will be assumed that both types of housing require the same amount of capital investment. Let $L_i^j(r)$ represent the rental price of land, which will also vary with distance. If in one unit of land k units of housing are built, this requires k units of capital; hence, the total rental price of housing can be assigned to the land and capital factors:

$$k\, R_i^j(r) = L_i^j(r) + P\, k.$$

That is,

$$R_i^j(r) = \frac{L_i^j(r)}{k} + P,$$

or

$$L_i^j(r) = k\ \left[R_i^j(r) - P\right] = k\ \left[\frac{Y^j - tr - z^j}{s^j} - P\right].$$

In all cities, at radius $\widehat{r}_i$ (the dividing point between low and high income housing) the land rents must coincide, that is

$$k\ \left[\frac{Y_i^A - t\widehat{r}_i - z^A}{\alpha} - P\right] = k[Y^B - t\widehat{r}_i - z^B - P].$$

At all locations, land is allocated to that activity yielding the highest return.

2.1 Equilibrium without planning restrictions

Equilibrium in the land market involves several conditions. Firstly, total population N^A and N^B must be accommodated within the boundaries of the cities. Secondly, if residents are perfectly mobile, the utility level achieved by each type of household will be the same in all cities. Since housing consumption is fixed and identical for individuals in the same income range, for them to be indifferent between cities their consumption of non-housing goods must also be the same. Finally, in a context without planning restrictions it is required that in all cities the urban land rent equals the value of the best alternative use at the city limit, usually considered to be agriculture.

In city i, $\widehat{r}_i$ units of land are allocated to low income households. If each unit of land has k units of housing, k/α households can be accommodated in it, since each household occupies α units of housing. Therefore, the total number of low income households that will reside in i will be

$$\frac{k\,\widehat{r_i}}{\alpha}.$$

Since the housing space occupied by each income category is the same across cities, in equilibrium it must be the case that all N^A low income households get accommodation:

$$\widehat{r_1} + \widehat{r_2} + \widehat{r_3} = \frac{\alpha N^A}{k}$$

The equilibrium condition for the high income households will be:

$$N^B = k\,\left[(r_1 - \widehat{r_1}) + (r_2 - \widehat{r_3}) + (r_3 - \widehat{r_3})\right]$$

Using the equilibrium condition for the low income households, we can rewrite the last equality as

$$r_1 + r_2 + r_3 = \frac{\alpha N^A + N^B}{k}.$$

The second condition implies that the consumption of private goods equals among cities, that is $z_i^j = z^j$. Finally, land rent equals the agricultural value at the city border. For simplicity, the value of land in agricultural use will be normalized to zero. Then $L^B(r_i) = 0$, or

$$Y^B - tr_i - z^B - P = 0.$$

The previous equation implies that $r_1 = r_2 = r_3 = r$, and from the condition that all population needs to be accommodated, it results:

$$r = \frac{\alpha N^A + N^B}{3k}.$$

Thus, in the non-restricted equilibrium, population is equally distributed across cities, and the low income households occupy an identical inner radius of

$$\hat{r} = \frac{\alpha N^A}{3k}.$$

Substituting the value of the city size in the zero land rent condition, we find the amount of z consumed by individuals with income Y^B, which is:

$$z^B = Y^B - P - \frac{t}{3k}[\alpha N^A + N^B].$$

For those with income Y^A:

$$z^A = Y^A - \alpha P - \frac{\alpha t}{3k}[N^A + N^B].$$

Notice that, in the absence of negative externalities caused by crowding, the higher the density level the better households are, since higher density allows savings in transportation costs and does not provoke any external costs. As we mentioned before, in our model density is measured by the variable k. In the following sections we will ignore all externalities. Therefore the consumption z of the composite good will allow us to measure how planning controls affect utility levels.

3 The effects of population controls

Consider that the planning instruments used are population controls that restrict the city size. The choice of the appropriate city size is endogenous in the sense that it maximizes a certain objective function. Two scenarios are considered. Firstly, the case where only one city in the system restricts its size; secondly, two of the cities impose population controls and they decide strategically.

3.1 Equilibrium with one controlling city

Begin by considering the case where only one city imposes population controls. The main difference with respect to the previous section is that for that city land rent need not be zero at the city border. The city size will be the one that maximizes aggregate land rents in the city. This objective function is commonly considered in the urban literature. The rationale for this objective function can be that higher land rents imply higher collection from property taxes, so the cities have more resources available. Thus, land rents act as a proxy for property tax collection. The chosen city size is smaller compared to the non-restricted scenario, but larger for the two non-controlling cities. In the system of cities the consumption of z will be smaller and the utility level lower.

Assume that city 1 imposes an urban population control that restricts city size, and that all excluded households can be accommodated in cities 2 and 3. There, the condition that urban land rent equals zero at the city limit continues to be valid. In equilibrium, since low income households get accommodation closer to the CBD, it can be assumed for all three cities land rents must still be equal at $\widehat{r_i}$. Now, using the population accommodation condition it results

$$z^B = Y^B - P - \frac{t}{2}\left[\frac{\alpha N^A + N^B}{k} - r_1\right],$$

where r_1 is now a choice variable for the local government in city 1. We have that, for all cities

$$\widehat{r_i} = \frac{\alpha N^A}{3k}.$$

In our case, population controls affect only high income households, while low income households are not affected at all in their actions, though, as we show next, their equilibrium utility will change. Since the relative steepness of land-rents functions does not change in the regulated situation, then $\widehat{r_i}$ does not vary with the introduction of population controls.

We obtain

$$z^A = Y^A - \alpha P - \frac{\alpha t}{2k}\left[\frac{(\alpha+2)}{3}N^A + N^B - k\, r_1\right].$$

With a population growth control in city 1, both z^A and z^B are negatively affected. The positive signs of the partial derivatives of z^j with respect to r_1 show that the consumption of goods other than housing increases with r_1, that is, the less restrictive the control is. Since housing consumption is exogenously determined, the population control makes residents worse off in this simple context without environmental externalities.

The above results apply whatever the values of r_1. Consider now the particular case when the population control introduced is endogenous, in the sense that it maximizes a particular objective function chosen by the local government. The objective function will be the sum of all land rents in city 1,

TR_1. Remember that the land rents benefit the absentee landowners. The local planner chooses the value of r_1 that maximizes the objective function TR_1, that is

$$\max_{r_1} \int_0^{\widehat{r_1}} k \left[\frac{Y^A - tr - z^A}{\alpha} - P \right] dr + \int_{\widehat{r_1}}^{r_1} k[Y^B - tr - z^B - P]\, dr. \quad (3.1)$$

The first order conditions of this maximization problem (obtained applying Leibniz's rule to differentiate the integral) result in a city limit r_1 smaller than the market equilibrium city size,

$$r_1* = \frac{1}{4k}[\alpha N^A + N^B].$$

Finally, z^B and z^A can be expressed in terms of the parameters:

$$z^B = Y^B - P - \frac{3t}{8k}[\alpha N^A + N^B],$$

and

$$z^A = Y^A - \alpha P - \frac{\alpha t}{8k} \left[\frac{(\alpha + 8)}{3} N^A + 3N^B \right].$$

It can be shown that, as should be expected, introducing the endogenous population control makes both types of residents consume smaller amounts of z^A and z^B, and as a result they attain smaller utility levels.

3.2 Equilibrium with two controlling cities

Consider next that cities 1 and 2 respectively impose the population controls r_1 and r_2, so as to maximize total land rents in each of the cities. Each community takes into account the rival's choice, what gives rise to a game between the two cities. It results that the best reply r_1 for city 1 is decreasing in r_2. The chosen equilibrium values r_1 and r_2 will be the Nash equilibrium values of the game. The solution of the game yields a city size for each active city that coincides with the optimal choice if one city alone were imposing the population control. The equilibrium utility level is smaller, though, and the size of city 3 results larger. In the following paragraphs we formally derive these results.

Assume then that cities 1 and 2 impose population controls in order to maximize their respective aggregate land rents, TR_1 and TR_2. Each city is aware of the other's policy and objective. This implies that there will be strategic interaction between both cities. In equilibrium, all households will end up by being accommodated. This is possible thanks to the passive role played by city 3, which just accommodates all households that go there.

In the case in which only one city imposes population controls, we saw that the size of the population of low income households was not affected by that policy. In this case the same thing will happen, and exactly for the same reasons. That is, the size of the low income household segment will be, for all cities, $\widehat{r} = \frac{\alpha N^A}{3k}$. Besides, in city 3 the condition that land rent equal zero at the city border holds, that is $L^B(r_3) = 0$. Hence the equilibrium levels of z^B and z^A will be given by:

$$z^B = Y^B - P - t\left[\frac{\alpha N^A + N^B}{k} - (r_1 + r_2)\right] \tag{3.2}$$

$$z^A = Y^A - \alpha P - \frac{\alpha t}{k}\left[\frac{(1+2\alpha)}{k}N^A + N^B - k(r_1 + r_2)\right]$$

The expressions imply that, as in the case in which only one city imposes controls, less stringent population controls lead to higher values of z^B and z^A, that is, to higher utilities.

The objective of city 1 is to maximize aggregate land rents TR_1. However, 1 has to consider 2's choice of r_2. This is achieved by combining z^B and z^A above together with the expression of TR_1 in 3.1. From the maximization of that expression, we find the best reply function for city 1:

$$r_1(r_2) = \frac{\alpha N^A + N^B}{3k} - \frac{r_2}{3}. \tag{3.3}$$

By symmetry, the expression of the best reply function of city 2 is:

$$r_2(r_1) = \frac{\alpha N^A + N^B}{3k} - \frac{r_1}{3}.$$

Notice that the best reply r_1 for city 1 is decreasing in r_2, that is, the strategies of both players are *strategic substitutes.*[2] Thus, if city 2 fixes a not too stringent (i.e. large) r_2, then city 1 benefits from choosing a smaller r_1. The land rent sacrificed by excluding a household is smaller the larger is the size chosen by the rival. A more stringent control increases the opportunity cost of losing population, and as a result cities choose larger sizes.

The system with the two best response functions for cities 1 and 2 gives rise to a game between the two cities, in which a Nash equilibrium will imply the choice of strategies by the two cities which are best replies to each other. Solving the system yields smaller sizes for cities 1 and 2, but a larger r_3. The expressions for the Nash equilibrium r_1 and r_2 coincide with the optimal

[2]Like the strategies of Cournot competitors. See Bulow, J.Geanakoplos and Klemperer (1985).

choice of one city if it alone were imposing the control:

$$r_{comp} = r_1 = r_2 = \frac{1}{4k}\left[\alpha N^A + N^B\right].$$

However, the equilibrium utilities achieved are smaller. Since more cities in the system impose population controls, this leads to a larger number of residents diverted to city 3, and consequently to higher land rents. The equilibrium values of z^B and z^A in this simultaneous population control game are:

$$z^B = Y^B - P - \frac{t}{2k}[\alpha N^A + N^B],$$

and

$$z^A = Y^A - \alpha P - \frac{\alpha t}{2k}\left[N^B + \frac{(2+\alpha)}{3}N^A\right].$$

Finally, we find the equilibrium land rents. Substituting the expression of $r_c omp$ back into the expression for land rent in city 1 in 3.1, and considering that both 1 and 2 use optimal growth controls, we obtain the expression for total land rents, denoted by TR_{comp} (where *comp* stands for *competitive*):

$$TR_{comp} = \frac{t}{288k}[11\alpha(N^A)^2 + 54\alpha N^A N^B + 27(N^B)^2 + 16\alpha N^A].$$

Figure 3.1 shows the relationship between aggregate land rents and city size under the assumption that the population controls chosen by cities 1 and 2 are identical. Since we know that both the noncooperative equilibria and the collusive solution are symmetric, they are included in the graphic.

It can be shown that land rents under competition are smaller to the maximum level of land rents attainable when cities coordinate their actions.

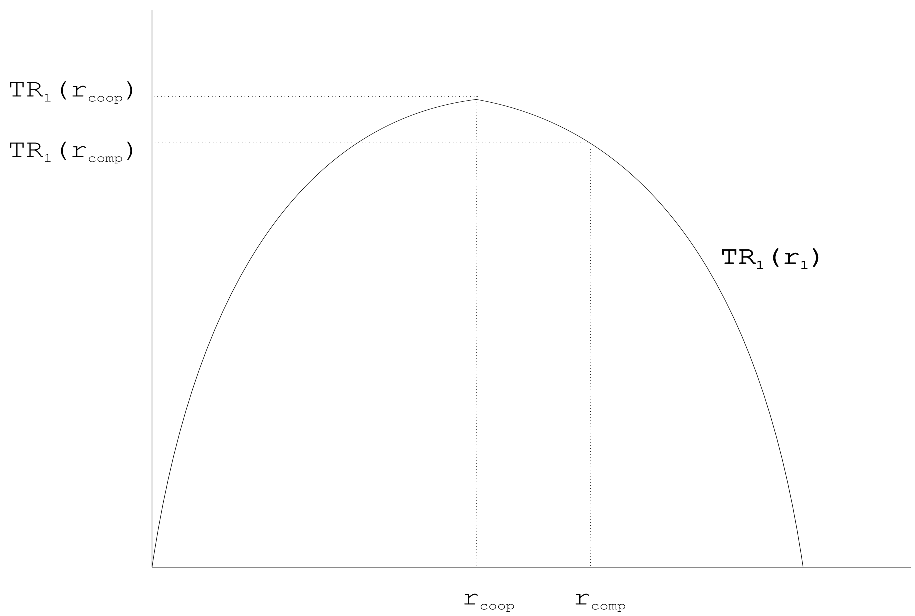

Figure 3.1: Total land rents with symmetric population controls

But still, cities have incentives to compete. In a static context, there exists a single Nash equilibrium in pure strategies in which both cities end up competing.

4 The effects of a tax on housing consumption

Other possible instruments to constrict city size are taxes that modify housing bid-rents of households, and consequently distort landowners' decisions of converting land from rural to urban. In this section we will consider a tax on housing. The rationale for introducing such a tax is to levy revenues that the community might want to use to finance public goods or services. The expense side of the tax, though, is not considered. Using this price instrument instead of a quantity instrument (size controls) as before, has different distributional consequences. The tax constitutes an additional expense for households.

City i will introduce a tax h_i, $0 < h \leq 1$, per unit of housing consumption. The residents' budget constraints will change to:

$$Y^j = z^j + tr + s^j\, R_i^j(r) + s^j\, h_i,$$

or, expressed in terms of the housing bid-rents:

$$R_i^j(r) = \frac{Y^j - tr - z^j}{s^j} - h_i.$$

The land bid-rent functions become:

$$\begin{aligned} L_i^B(r) &= k\, \left[Y^B - tr - z^B - h_i - P\right] \\ L_i^A(r) &= k\, \left[\frac{Y^A - tr - z^A}{\alpha} - h_i - P\right]. \end{aligned}$$

4.1 Equilibrium values when one city uses taxes

Here we first derive the relationship between the tax on housing, on the one hand, and the city size and utility level, on the other. The tax acts as an additional expense for households, and this makes the housing bid-rent and the land rent values to decrease. This translates into a diminishment of the city size. The reason is that the agricultural land rent exceeds the urban one at a shorter distance from the CBD. It is considered the case in which one city alone uses a tax on housing. The tax size is chosen as the result of the maximization of the fiscal revenue achieved through taxes, with the revenue depending upon the size of the tax and the number of households in the city (related to the city size). The optimal tax yields a smaller city size compared to the non-restricted scenario, and utility diminishes with the introduction of the tax.

See how new land rent functions differ from the one in the market situation because of the new tax on housing, h_i. In equilibrium, it must be true that $L_i^B(r_i) = 0$, independently of whether or not the city uses a tax. When only 1 introduces the tax h_1, then $r_2 = r_3 = r$, and since in equilibrium z^B is common to all cities, we have:

$$r = \frac{\alpha N^A + N^B}{2k} - \frac{r_1}{2}.$$

Since $L^B(r_1) = 0$, we can use the expression of z_b in 3.1 to express the size of 1 in terms of the tax h_1:

$$r_1 = \frac{\alpha N^A + N^B}{3k} - \frac{2h_1}{3t}. \tag{4.1}$$

Notice the linear and negative relationship between the tax and the size of the city. With the introduction of the tax on housing consumption, housing rents reduce, as land rents do. Therefore city 1 will be smaller. Now we can find the expressions for z^B and z^A in terms of the housing tax h_1:

$$z^B = Y^B - P - \frac{t}{3k}[\alpha N^A + N^B] - \frac{h_1}{3},$$

and

$$z^A = Y^A - \alpha P - \frac{\alpha t}{3k}[N^A + N^B] - \frac{\alpha h_1}{3}.$$

We assume again that $\widehat{r_i} = \widehat{r} = \frac{\alpha N^A}{3k}$. Examining the effect of h_1 on z^A and z^B, we see that as the housing tax increases the consumption of z^A and z^B decreases, as does utility.

A population constraint and a tax on housing consumption that result in the same city size have the same negative effect on households, who in either situation reach identical utility levels and the same consumption of z. The result is natural, since both interventions affect households in the same way: the housing consumption tax acts as an additional expense, while the population control causes housing rents to increase. In both scenarios, the income that can be dedicated to non-land goods shrinks.

On the other hand, a tax on land instead of on housing would cause the city to become smaller as well, and residents to attain higher utility levels, but land owning would become less profitable in city 1.

Notice, however, that population controls and taxes have different distributional consequences. With population controls, landowners of developed land receive higher land rents, while residents experience a reduction in their utility levels. When the housing consumption tax is used, resident households experience a comparable decrease in z and the utility level, but all landowners in the city lose too. Instead, the local authority benefits from all aggregate housing consumption taxes.

What tax level would the local government choose if its objective were to maximize the sum of aggregate taxes (Rh_1) levied from residents in city 1? Since the tax affects both the city size and the number of households, the objective function of the local authority is

$$Rh_1 = h_1 k r_1 = h_1 k \left[\frac{\alpha N^A + N^B}{3k} - \frac{2h_1}{3t} \right]. \tag{4.2}$$

Maximizing the above expression with respect to h_1 yields the optimal value, h_1^*, which is

$$h_1^* = \frac{t}{4k} \left[\alpha N^A + N^B \right].$$

This optimal tax corresponds to a city size

$$r_1^* = \frac{1}{6k} \left[\alpha N^A + N^B \right].$$

After substituting the value of the optimal tal in the expressions of z^B and z^A, we obtain:

$$z^B(h_1^*) = Y^B - P - \frac{5t}{12k} [\alpha N^A + N^B],$$

and

$$z^A(h_1^*) = Y^A - \alpha P - \frac{\alpha t}{12k} [5N^B - (4 + \alpha) N^A].$$

Both levels of (private goods) consumption are smaller compared to the ones achieved in the market situation. The effects on z would be identical if directly using a population control leading to the city size achieved when using h_1^*. Residents lose in a similar way both with taxes and population controls. On the contrary, landowners gain with the introduction of the population control, but are worse off with the tax on housing that ultimately diminishes land rents. Likewise, landowners of undeveloped land become worse with the tax. Local communities benefit, because they receive the tax revenues.

4.2 Equilibrium values when two cities use taxes

As with the population growth control case, consider now that all cities in the system except for the passive city 3 impose taxes on housing consumption. Thus, 1 and 2 enact taxes h_1 and h_2, after maximizing their respective fiscal revenues. In order to maximize the tax revenue, city 1 must now consider the behaviour of all other *active* cities, and so must city 2.

A first difference with respect to the use of population controls is that taxes of different cities relate positively, i.e. the tax chosen by one city increases as does the rival's tax. The equilibrium values of h_1 and h_2 again are found as the Nash equilibrium solutions of the game. A second difference is that the chosen tax now changes compared to the optimal tax when only one city uses taxes. In particular, it is smaller. Consequently, the city size for each active city is larger than in the one controlling city case. The equilibrium utility level does decrease, compared to the same one-controlling city scenario. We now obtain these results analytically.

The general expression for z_B in 3.2 will determine the level of z^B in the system, common to the three cities. Applying the condition that $L^B(r_1) = L^B(r_2) = 0$, z^B can be expressed exclusively in terms of the taxes applied by cities 1 and 2. Thus

$$z^B(h_1, h_2) = Y^B - P - \frac{t}{3k}[\alpha N^A + N^B] - \frac{1}{3}[h_1 + h_2].$$

And from the condition that land rents equal at $\widehat{r}_i$, we find that

$$z^A(h_1, h_2) = Y^A - \alpha P - \frac{\alpha t}{3k}[N^A + N^B] - \frac{\alpha}{3}[h_1 + h_2].$$

The expression for r_1 is computed similarly:

$$r_1 = \frac{\alpha N^A + N^B}{3k} + \frac{1}{3t}[h_2 - 2h_1].$$

The objective of city 1 will be again to maximize tax revenues, but now taking into account the decision adopted by city 2. Using the expression of r_1 just obtained, we can write the maximization problem for 1:

$$\max_{h_1} \; h_1 k \left[\frac{\alpha N^A + N^B}{3k} + \frac{1}{3t}(h_2 - 2h_1) \right],$$

The solution is the best response function for city 1:

$$h_1(h_2) = \frac{t(\alpha N^A + N^B)}{4k} + \frac{h_2}{4}.$$

By symmetry, we can see that the best response function for city 2 is:

$$h_2(h_1) = \frac{t(\alpha N^A + N^B)}{4k} + \frac{h_1}{4}.$$

Notice that the sign of the partial derivatives of the reaction functions is positive. Contrary to what happened in the population control game, now the best response functions slope upward in the tax game. This means that taxes as growth control instruments act as *strategic complements* rather than substitutes.[3] When 2 chooses a relatively high tax, more households are diverted to the remaining cities in the system, including 1, since the decision is made considering that h_1 remains fixed, but not the population level in 1. By imposing a higher h_1 it is possible to increase the revenue levied from those diverted households.

[3] Like the strategies of Bertrand competitors. See Bulow et al. (1985).

The equilibrium is found by solving the system of equations formed by the two reaction functions. The equilibrium taxes are:

$$h_{comp} = h_1 = h_2 = \frac{t}{3k}[\alpha N^A + N^B].$$

The tax revenue that corresponds to the equilibrium taxes is

$$Rh(h_{comp}) = \frac{2t}{27k}[\alpha N^A + N^B]^2$$

for any of the cities enacting taxes. The resulting city sizes are

$$r(h_{comp}) = \frac{2}{9k}[\alpha N^A + N^B].$$

This city size is larger than in the one controlling city case, and it is smaller than the size obtained in the population control game. Other studies have shown that price instruments lead to higher equilibrium populations (Helsley and Strange, 1995). However, comparisons must be carefully made, since different objective functions have been used for the population and the tax control games. Alternatively, the total level of revenues should be compared. This comparison will be further explored in an upcoming section. As for the levels of z^A and z^B which ultimately affect the levels of utility in the system, we find that

$$z^B(h_{comp}) = Y^B - P - \frac{5t}{9k}\,[\alpha N^A + N^B],$$

and

$$z^A(h_{comp}) = Y^A - \alpha P - \frac{\alpha t}{9k}\,[5N^B + (3 + 2\alpha)N^A].$$

The consumption of non-land goods diminishes when introducing strategic interaction between cities, for both types of households, again compared to the outcome in which there is a single controlling city. As the number of cities using taxes increases, the negative effects on z are more important, because the number of households that are diverted from the controlling cities is larger. This causes housing and land rents in city 3 to increase.

Similarly to the population control case, competing becomes the equilibrium strategy in a single-period setting, even though a coordinated action by cities would leave to higher fiscal revenues.

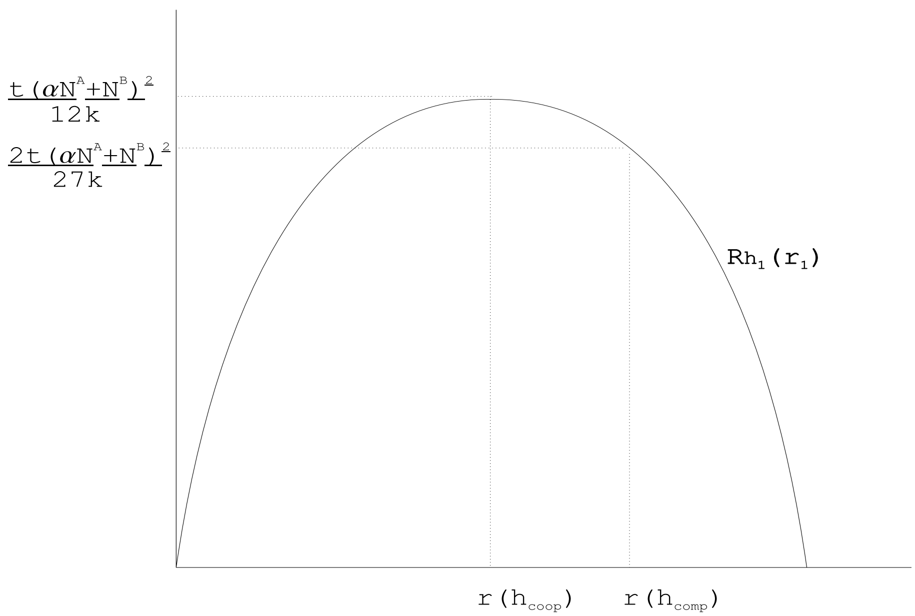

Figure 4.1: Tax revenues with symmetrical tax levels

5 Comparison of results with population controls and taxes

We have so far assumed that the housing tax and the population controls were endogenous, in the sense that they maximize the respective objective functions set by the local communities. In this section, aggregate taxes levied are compared depending on the instrument used. Because households' utility levels do not depend upon any local public good or urban amenity, the expenditure side of the tax collection is being ignored. It can be likewise argued that the positive effect on households' utility of this expenditure would be the same for a constant level of tax revenues, and then only the negative effects associated with the particular source of the fiscal revenue matter.

To compare the different effects of using population controls or taxes for collection purposes, we make the following assumption. Taxes on housing directly yield a certain amount of tax revenue. As for the population control effect on fiscal revenues, two extreme scenarios can be considered. Firstly, it could be the case that only increased land rents were taxed, for instance if the whole increase in land rents was captured by the local government. The second possibility consists of assuming that the local community imposes a certain tax p on total land rents, not only on value increases. (For instance, with $p = 1$ the local community would appropriate all land rents. Obviously, such an extreme tax would cause landowners to lose all incentives to efficiently allocate each plot of land to the highest bidder.)

The comparison of tax revenues under each instrument will be simpler if we represent each revenue level against the associated city size r_1, as in figure 5.1. The graph plots the revenue size associated with each city size, under three different scenarios: housing tax competition, population controls such that the tax revenue equals the increased land rents, and population controls such that the tax revenue equals *all* land rents. In all cases only symmetric solutions are considered.

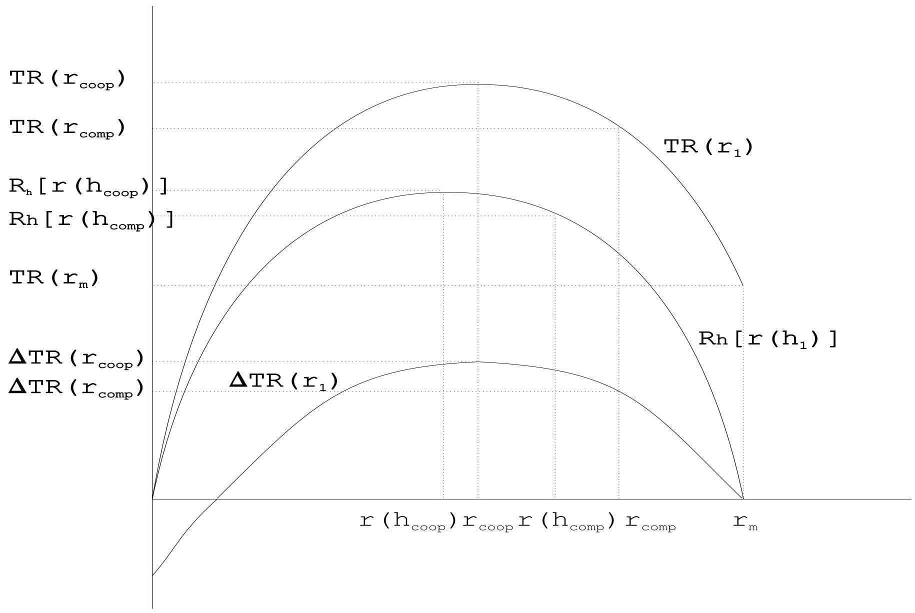

Figure 5.1: Comparison of tax revenues with population controls and housing taxes

The relationship between land rents –or increased land rents– and city size is straightforward. As for the relationship between housing tax revenues and city size, it can be easily obtained by combining the expression of housing tax revenues in equation 4.2 with the expression in equation 4.1 that relates the housing tax level h_1 with the city size r_1. Each housing tax level is uniquely associated to a certain city size. As can be observed, the three revenue curves have a Laffer type shape. Thus, a small city size can represent either the utilization of a too stringent population control or the result of a relatively high tax on housing consumption. A smaller city is associated then either to a large increase in land rents or to to a higher housing tax. Both facts provoke a greater per capita revenue, but a reduction in the base of the revenue due to the fact that less residents remain in the city in equilibrium. Several city sizes have been highlighted: r_m, which represents the city size corresponding to the market situation; r_{comp}, the equilibrium city size when competing with population controls; $r(h_{comp})$, the city size obtained when competing with housing taxes; r_{coop}, the city size when cities set cooperatively their population controls; and $r(h_{coop})$, the resulting city size when cities cooperate to fix their housing taxes.

A city size of r_m corresponds to a situation where there is no population control or a tax $h_1 = 0$, and as a result $Rh = 0$ and $\Delta TR_1 = 0$. Total land rents equal the market value, that is TR_m.

When the increases in land rent values due to the introduction of population controls are fully taxed, housing taxes are always superior to population controls, because a fixed revenue level can be achieved at a smaller cost in terms of the decrease in residents' utility. The optimal city size when maximizing increased total land rents ΔTR_1 is $r_1 = (1/5k)[\alpha N^A + N^B]$ —the city size that maximizes aggregate land rents TR_1. The revenues arising from the implementation of a tax on housing leading to the same city size are greater. Alternatively, the revenue obtained with this city size, $\Delta TR_1 = \frac{t}{144k}[\alpha N^A + N^B]^2$, could be attained with a housing tax level leading to a greater city size –and as a result, with a smaller loss in residents' utility. For values of the city size greater than the optimal level r_1, the diverting of population caused by a direct population control provokes that total revenues begin to decline, up to the city size $r_1 = \frac{1}{6k}(\alpha N^A + N^B)$, which implies again that $\Delta TR_1 = 0$.

Secondly, consider a tax that levies total land rents, and not only land rent rises. Under this scenario, the comparison between housing taxes and population favors the population control instrument, since total land rents are always superior to taxes in terms of total revenue for identical city sizes. Under this total confiscation of land rents, the problem is that landowners have no incentive to efficiently allocate their land.

There exists an intermediate tax rate p that could be applied on total land rents, that would lead to identical outcomes in terms of tax revenues. Analytically, this p tax rate can be expressed in terms of the parameters, but its (complicated) expression adds no further intuition.

6 Conclusions

There exists a great deal of studies dealing with models of fiscal competition at the regional or local level. They explore how .... Likewise, this paper focuses on the fiscal consequences of a certain type of competition among urban areas, the one taking place when planning the future growth of cities. Thus, urban regulations are contemplated as the result of strategic interaction among local jurisdictions. Two different instruments are analyzed and compared in terms of the fiscal revenue they yield, namely population controls and taxes on housing.

Measured in terms of total fiscal revenues, population controls are superior to housing taxes only when all land rents are confiscated, that is, when aggregate land rents are penalized with a 100% tax. This extreme scenario would lead to a lack of efficiency in the system, since landowners would no longer have the incentives to allocate their land to the higher bidder.

When the increases in land rent values due to the introduction of population controls are fully taxed, housing taxes are always superior to population controls, because a fixed revenue level can be achieved at a smaller cost in terms of the decrease in residents' utility.

The framework here presented opens up the possibility and the necessity to carry out future work to explore other interesting issues that would make the model closer to reality. A first shortcoming of the study is that it does not account for the expense side of the tax. In this sense, this expense side could be included in the form of the provision of a local public good to be financed through levied taxes. This would likewise justify the use of urban planning restrictions from the perspective that they are set to benefit cities' residents. Another extension could go in the direction of analyzing the fiscal impacts of alternative planning instruments, not treated here. This would include impact fees or density restrictions, for example.

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