Welfare Effects of Anti-Sprawl Policies in the Presence of Urban Decline

Antonio M. Bento, Sofia F. Franco, and Daniel Kaffine

This paper extends first-best analysis of anti-sprawl policies, such as development taxes, and examines the welfare effects of development taxes in the presence of urban decline at the city core. We find that anti-sprawl policies generate several important feedbacks within the urban system, generating additional welfare gains and affecting the level of urban decline and suburban sprawl. Further, the optimal development tax exceeds the (first-best) Pigouvian level, irrespective of whether or not revenues are returned lump-sum to all landowners or earmarked for urban decline mitigation.

Key Words: urban sprawl, development taxes, second-best policies, spatial modeling

Two trends characterize the evolution of metropolitan areas in the United States. Many central cities of major metropolitan areas are in decline relative to the suburbs, and at the same time, metropolitan areas are also experiencing rapid development in their outer suburban areas.[1]

Some argue that this pattern of land development is inefficient, leading to losses of open space, excessive commuting, increases in the cost of providing public services, civic disengagement, and even obesity.[2] Market failures including undervaluation of open space at the urban fringe, unpriced traffic congestion, and underpriced urban infrastructures have been identified as causes of urban sprawl (Brueckner 2000). As a consequence, policymakers, urban planners, and public policy analysts have called for more stringent policies to strengthen the urban core and to discourage suburbanization.

Economists have often advocated for market-based instruments, such as development taxes, to curb urban sprawl.[3] As argued in Brueckner (2001) and Bento, Franco, and Kaffine (2006), if the only market failure leading to urban sprawl is undervaluation of open space at the urban fringe, then the social optimum can be achieved either by a development tax equal to vacant land's amenity value per acre, or by an urban growth boundary (UGB) set at the appropriate distance from the urban center.

However, the presence of additional urban spatial market failures can potentially alter this standard Pigouvian prescription. For example, urban decline can generate negative spillovers on adja-

Antonio M. Bento is Associate Professor in the Dyson School of Applied Economics and Management at Cornell University in Ithaca, New York. Sofia F. Franco is Associate Professor in the Department of Economics and Management at the Universidade Lusófona de Humanidades e Tecnologias, in Lisbon, Portugal, and also a research member of UECE-Research Unit on Complexity and Economics, ISEG-UTL, also in Lisbon. Daniel Kaffine is Assistant Professor in the Division of Economics and Business at the Colorado School of Mines, in Golden, Colorado.

This paper was presented at the workshop "The Economics of Land Use Change: Advancing the Frontiers," organized by Lori Lynch (Center for Agricultural and Natural Resource Policy, University of Maryland) and Jacqueline Geoghegan (Clark University), in Washington, D.C., June 25–26, 2009. The workshop received financial support from the U.S. Environmental Protection Agency, the Lincoln Institute of Land Policy, and the Center for Agricultural and Natural Resource Policy at the University of Maryland. The views expressed in this paper are the authors' and do not necessarily represent the policies or views of the sponsoring agencies.

[1] There is a growing body of literature on the economics of urban sprawl surveyed in Glaeser and Khan (2004) and Nechyba and Walsh (2004). For important contributions to the modeling of the causes of sprawl, see Brueckner (2000), Cheshire and Sheppard (2002, 2003), Burchfield et al. (2006), Wu (2006), and Irwin and Bockstael (2007).

[2] Wu and Plantinga (2003) examined the effects of public open space policies on urban spatial structure. Geoghegan, Lynch, and Bucholtz (2003) estimate the value of open space on neighboring residential areas. Bento et al. (2005) examined the impacts of sprawl on vehicle ownership, vehicle miles traveled, and public transit ridership. Plantinga and Bernell (2007) and Eid et al. (2008) examined the link between urban sprawl and obesity. Brueckner and Largey (2008) examined the links between urban sprawl, social interactions, and neighborhood density.

[3] Recently, Banzhaf and Lavery (2010) have confirmed that development taxes can be an effective tool to curb urban sprawl. In particular, the authors find empirical evidence that the adoption of a split-rate tax in Pennsylvania has increased the capital/land ratio.

cent areas (Ellen et al. 2003) and potentially affect suburban sprawl. In addition, anti-sprawl policies can affect landowners' private decisions to mitigate central city decline. Anti-sprawl policies can shift population towards the city center, increasing housing demand and central city housing prices and, thus, increasing reinvestment incentives (Brueckner and Helsley 2011). In addition, some anti-sprawl policies such as development taxes also generate revenues that can be recycled into declined areas of the city, influencing individual reinvestment efforts (Bento, Franco, and Kaffine 2009). The importance of these feedback effects and their impacts on the welfare effects of development taxes has been typically overlooked in the urban sprawl literature. Our goal here is to fill this important gap in the literature.

To inform policymakers engaged in setting anti-sprawl policies, this paper answers three key questions. First, what are the welfare effects of development taxes in the presence of urban decline at the city core? Second, how should the optimal development tax be set when there are empirically important interactions between urban decline and anti-sprawl policies? A related issue is how this (second-best) development tax compares to the (first-best) Pigouvian level. Third, can a development tax be justified even when the benefits of open space are negligible? In other words, should an anti-sprawl policy be part of the local tax system, even if there are uncertainties on the magnitude of the direct benefits of anti-sprawl policies?

The framework used to answer these questions follows closely that of Bento, Franco, and Kaffine (2009, 2011). Specifically, we develop a spatially explicit monocentric circular open city model with two market distortions that affect development decisions at the urban fringe: under valuation of open space at the urban fringe, and urban decline at the city core that potentially affects development at the urban fringe. We define urban sprawl as an excessive outward expansion of urban development relative to what is socially efficient, and we define urban decline as spatial concentration of deficient housing maintenance or reinvestment.[4]

Our framework captures an important empirical regularity that suggests that the presence of urban decline at the city core potentially affects development at the urban fringe.[5] As shown in Brueckner and Helsley (2011), the interactions between the city core and suburbs can generate additional spillovers that promote suburban sprawl and urban decline. In their closed city framework, urban decline increases the desirability of suburban locations, thereby increasing urban sprawl. However, it is also known that severe urban decline has strong negative spillover effects on other properties within a city (Santiago, Galster, and Tatian 2001, Ellen et al. 2003, Schwartz et al. 2006, Rossi-Hansberg, Sarte, and Owens 2009), which may also decrease the competitiveness of a particular metropolitan area in attracting households and businesses.[6] In this latter scenario, competition for residents between central cities and suburban areas is less fierce, and urban decline can even lead to a decrease in urban sprawl. The decline of central cities can affect an entire metropolitan region negatively through amenities, agglomeration economies (benefits that firms get from locating near each other), and social problems. When a central city is declining—i.e., experiencing negative population growth and a deteriorating tax base due to a flight for the suburbs—the amenities that it can offer its residents

[4] In our model, urban decline arises from the interaction of neighborhood externalities that influence individual maintenance or reinvestment decisions. The process fueling spillovers throughout the urban area begins with the presence of urban decline at the center. However, the impacts on the metropolitan area development would have been the same had urban decline been located at the urban fringe. In our context, the presence of urban decline, independent of its geographical location, alters the pattern of metropolitan investment, therefore reducing the city's capacity to pursue goals such as competitiveness.

[5] In related work, Anas and Rhee (2006) provide a numerical appraisal of congestion tolls and UGBs in a city that is congested, but their framework differs substantially from the standard monocentric model. Brueckner (2007) re-examined the effectiveness of UGBs as second-best instruments in a monocentric congested city. In the most closely related work, Brueckner and Helsley (2011) consider both urban decline and urban sprawl; however, it should be noted that in their treatment, links between urban decline and urban sprawl are generated by competition between suburban and urban properties for a fixed number of residents. In our open city framework, the number of residents is endogenous.

[6] Albouy (2008) uses a Rosen-Roback framework to generate city-level rankings of quality of life and to infer the value to consumers of various local public goods and city characteristics. The estimates show that households have a high willingness to pay (WTP) to live in places with many eating and drinking establishments, and arts and culture. To the extent that density correlates with supporting public goods like arts and culture, then the increases in density due to urban decline mitigation could generate city-wide increases in utility, and make the city more attractive to residents.

diminish as well. But this is not only a problem for the city in question since some of these amenities (cultural institutions, vibrant pedestrian districts, waterfront parks, libraries, etc.), although tied to a single locality, are valued by an entire region. When a continuous outflow of residents from the urban core hinders the declining community from providing basic public services and regional amenities such as these, it ends up making the entire metro area less desirable. Part of the allure of a New York City suburb is that it is right outside New York, while a precious few, if any, move to the Detroit metro area because of what Motown can offer.[7]

This link between urban decline and sprawl provides a potential rationale for recycling revenues of development taxes through a subsidy to housing improvements. Below, when evaluating the welfare effects of development taxes, we contrast this form of revenue-recycling with a standard recycling scheme where all revenues are lump-sum redistributed to landowners.

We find that when revenues from the development tax are returned lump sum, the welfare effects of this policy can be decomposed into two main channels. The first is the traditional *Pigouvian welfare effect*, which is the efficiency gain associated with households responding to the higher level of open space by increasing their bids for housing, net of the cost associated with the reduction in the total amount of land developed at the urban fringe. Second, by increasing bid rents throughout the city, private housing improvements are stimulated, leading to an additional welfare channel, the *aggregate improvement effect.* This represents the efficiency gain from capitalization of urban decline mitigation.

In contrast, when development tax revenues are recycled in the form of housing improvement subsidies, an additional welfare channel emerges: the *revenue-recycling effect*. By subsidizing private mitigation of urban decline, additional welfare changes arise from capitalization of these improvements. As a result of the *aggregate improvement effect* and *revenue-recycling effect*, the optimal development tax should be set higher than the Pigouvian level. In fact, when revenues are recycled to subsidize housing improvements, a positive development tax may be justified even when household valuation of open space is negligible.

We also illustrate that feedbacks between anti-sprawl policies and urban decline can affect the level of suburbanization. In the case where the revenues from the development tax are returned lump-sum, mitigation of urban decline induced by the increase in open space creates a feedback effect, potentially increasing development pressure at the urban boundary. This occurs because the attractiveness of an urban area increases when the amount of open space near the urban area increases and the level of urban decline decreases, thereby attracting more population into the area. Achieving a given reduction in the level of suburbanization thus requires a larger development tax than the case when these feedback effects are absent. These feedback effects are further increased when development tax revenues are recycled in the form of housing improvement subsidies. In fact, the city boundary may even *increase* when revenues are recycled. This suggests that policymakers interested in curbing suburban sprawl must be mindful of potential feedbacks throughout the urban system that can affect development decisions at the urban boundary and the distribution of the population across space.

The rest of the paper is organized as follows. Next we introduce the analytical model and assumptions. Then we decompose the welfare effects of the development tax, the corresponding changes in open space, and the optimal development tax. Finally, we offer conclusions.

Analytical Framework

The analytical framework presented here follows closely that of Bento, Franco, and Kaffine (2009, 2011). There are two market failures in the model: under-priced open space amenities at the urban fringe, and urban decline at the city center.

City

The city is circular, open, and monocentric, with a predetermined urban center—the CBD—on a featureless plane with no topographical and regulatory constraints. Two competing land uses are possible in the city: agriculture and residential

[7] In addition, when central cities experience urban decline, agglomeration economies follow suit. Individual firms that benefit from these may then pick up their operations and relocate to another area that offers stronger network effects.

use. Land is owned by absentee landowners. Both land and the housing markets are competitive. Each parcel of land is sold to the highest bidder and housing is supplied to the household bidding the highest amount. The presence of the externalities discussed below implies that the resulting laissez-faire equilibrium will not be economically efficient.

Open Space Amenities

Land in agricultural use, Ag, generates an exogenous rent r_a, as well as open space amenities. The total amount of agricultural land is given by

$$Ag = \pi(m^2 - \overline{x}^2), \tag{1}$$

where m is the exogenous geographical boundary of the total amount of land that can be allocated to residential use and agriculture, and $\overline{x}$ is the city boundary—that is, the endogenous border between agriculture and residential use.

For simplicity, we assume that open space amenities, O, are linear in the amount of land allocated to agricultural use:

$$O(Ag) = Ag = \pi(m^2 - \overline{x}^2). \tag{2}$$

Households

Each household enjoys utility from housing (H), a composite consumption good (Z), and open space amenities around the city (O), and is adversely affected by the level of urban decline in the city center [$D(x)$].[8] The household utility function is represented by:

$$U\ [u(H,Z),O,D(x)], \tag{3}$$

where $U(\cdot)$ is continuous, quasi-concave, and weakly separable in $u(\cdot)$, O, and $D(x)$.[9] The household budget constraint is given by $Z + pH = y - tx$, where p is the rental price of H, y is household income, t is the transportation cost per mile, and x is distance, in miles, from the place of residence to the place of work. For simplicity, we set the price of the composite good equal to unity.

Households choose x, Z, and H to maximize utility (3) subject to the budget constraint, taking the level of open space and urban decline as given. From the resulting first-order conditions we obtain the uncompensated demand functions for the composite good and housing, conditional on x: $Z(y-tx,\ p)$ and $H(y-tx,\ p)$. Substituting these equations into (3) gives the indirect utility function:

$$V[y-tx, p, O, D(x)]. \tag{4}$$

For any given structure of housing prices in the city, households prefer those locations that provide the highest level of utility. In equilibrium, the usual spatial arbitrage argument implies that all locations that are occupied by households must have rents that allow a common level of utility $\overline{V}$ to be achieved. Therefore, a representative household chooses x that maximizes (4), and p adjusts so that

$$V\ [y-tx, p, O, D(x)] = \overline{V}. \tag{5}$$

Equation (5) implicitly defines the housing bid rent function as

$$p\ [y-tx, O, D(x), \overline{V}]. \tag{6}$$

Equation (6) describes the maximum rent per unit floor area that a household is willing to pay at distance x from the CBD if it is to receive a given level of utility $\overline{V}$. It is important to observe that the levels of open space and urban decline affect equilibrium prices (housing rents) and, ultimately, the levels of housing density.

[8] Note that the effects of urban decline are allowed to vary with location x but the benefits of open space at the urban fringe accrue homogenously to households living throughout the city. While empirical studies have noted that the valuation of open space depends on its total amount and accessibility (e.g., Anderson and West 2006, Irwin 2002, Geoghegan 2002, Geoghegan, Lynch, and Bucholtz 2003, McConnell and Walls 2005), explicitly modeling the spatial amenities of open space would make the analysis more cumbersome without changing our analytical results, and as such we have abstracted from such spatial considerations.

[9] The separability restriction implies that the demands for H and Z do not vary directly with changes in O and $D(x)$, though it should be noted that these demands can vary indirectly through price feedbacks. This is a common simplifying assumption. Using a more general utility function would not affect the key results.

Housing Supply and Housing Quality

Housing floor space is produced with land and capital according to a strictly concave, constant-returns production function. The intensive form of the production function is given by the concave function $h[S(x)]$, where $S(x)$ is capital per unit of land (structural density) at location x. Construction costs $C^S[S(x)]$ are a continuous convex function.

We assume that there are two components of decline at each location x, $D(x)$: the quality of the local housing stock, $Q(x)$, and the aggregate quality of the housing stock, A, such that $D(x) = D[Q(x), A]$ and $D_Q < 0$, $D_A < 0$.

The quality of the local housing stock is defined as

$$(7) \qquad Q(x) = \bar{Q} - \delta(x) + I(x),$$

where $\delta(x)$ is an exogenous level of physical deterioration of the housing stock at location x, and $I(x)$ is the level of housing improvements that landowners can choose to undertake.[10] $\bar{Q}$ represents the "maximum" housing stock quality, with no deterioration or needed improvements. Let $\bar{x}_D$ represent the exogenous boundary of houses exhibiting physical deterioration, and assume that housing locations $x < \bar{x}_D < \bar{x}$ exhibit some level of physical deterioration, while houses near the urban boundary do not. According to (7), the quality of the housing stock near the CBD can be fully or partially offset by housing improvements: $0 \le I(x) \le \delta(x)$. Total improvements are thus given by

$$(8) \qquad \bar{I} = \int_0^{\bar{x}_D} I(x) 2\pi x dx.$$

Housing improvement costs are given by $C^I[S(x), I(x)]$, which is continuous and convex. The aggregate quality of the city's housing stock in the current period is thus represented by

$$(9) \quad A = \int_0^{\bar{x}_D} Q(x) 2\pi x dx = \int_0^{\bar{x}_D} [\bar{Q} - \delta(x)] 2\pi x dx + \bar{I},$$

where $\bar{x}$ is the (endogenous) city boundary. Thus, improvements made at a given location, $I(x)$, increase the local quality of the housing stock, $Q(x)$, which also increases the aggregate quality of the housing stock, A. This increase in aggregate housing quality is in turn capitalized into housing prices across the city per equation (6). Specifically, local housing improvements are capitalized into local housing prices through

$$\frac{\partial p}{\partial D} \frac{\partial D}{\partial Q} \frac{dQ}{dI} > 0,$$

and aggregate housing improvements are capitalized throughout the city via

$$\frac{\partial p}{\partial D} \frac{\partial D}{\partial A} \frac{dA}{d\bar{I}} > 0.$$

Landowners

The return per acre of land in residential use at a particular location x is defined from the zero profit condition as

$$(10) \quad r(\cdot, x) = \max_{I(x), S(x)} p[y - tx, O, D(x), \bar{V}] h[S(x)] - C^S[S(x)] - C^I[S(x), I(x)].$$

A landowner at location x chooses the level of structural density, $S(x)$, and the level of housing improvements, $I(x)$, taking into account (7), in order to maximize (10).[11] If the exogenous return in agriculture, r_a, is less than the return in residential use, $r(\cdot, x)$, land is converted into residential use. From this maximization problem we obtain the optimal structural density and the optimal level of improvements, respectively, as

$$(11a) \qquad S^*[y - tx, O, \delta(x), \bar{I}, \bar{V}] \ge 0 \text{ and}$$

$$(11b) \qquad I^*[y - tx, O, \delta(x), \bar{I}, \bar{V}] \ge 0.$$

[10] Our analysis uses a static framework, and thus for simplicity we have not modeled the dynamic process that has led to the deterioration of the housing stock in the current period. Reasons for the presence of housing deterioration in a certain period include housing durability (Glaeser and Gyourko 2005), construction costs (Gyourko and Saiz 2003), and externalities from individual behaviors (Kutty 1995).

[11] See the appendix for first-order conditions of the maximization problem.

Equations (11a) and (11b) highlight several important features of the model. Because housing bid rents capitalize housing quality, structural density and private improvements depend on both the (exogenous) physical deterioration of the local housing stock $\delta(x)$ and aggregate housing improvements $\overline{I}$. In addition, because changes in open space O are capitalized into housing prices, this feedback can affect both structural density and improvement decisions.[12]

The Equilibrium

The urban equilibrium is determined by two conditions. First, residential land rent must equal the agricultural rent r_a at the city boundary, $\overline{x}$:

$$(12) \qquad r(y - t\overline{x}, O, \overline{I}, \overline{V}) = r_a .$$

The city boundary, $\overline{x}$, is established in the land market and is implicitly determined by (12) as

$$(13) \qquad \overline{x}(y, t, O, \overline{I}, \overline{V}, r_a) .$$

From (2), the total amount of open space amenities is implicitly given by

$$(14) \qquad O = \pi\, [m^2 - \overline{x}^2(y, t, O, \overline{I}, \overline{V}, r_a)] .$$

The second urban equilibrium condition determines how many residents, N, the city accommodates:

$$(15) \qquad \int_0^{\overline{x}} \frac{h(S[y - tx, O, \delta(x), \overline{I}, \overline{V}])}{H[y - tx, O, \delta(x), \overline{I}, \overline{V}]} 2\pi x dx = N ,$$

where

$$\frac{h(S[y - tx, O, \delta(x), \overline{I}, \overline{V}])}{H[y - tx, O, \delta(x), \overline{I}, \overline{V}]}$$

is the population density at x miles from the CBD, which is the ratio between square feet of floor space per acre of land and square feet of floor space per dwelling.

Equation (15) shows that in a circular city, all households must find a house somewhere within a radius $\overline{x}$, the city boundary. Because the city is open, costless migration ensures that the urban households are neither better off nor worse off than households in the rest of the urban economy. In this case, the urban utility level is fixed exogenously, and population N becomes endogenous, adjusting to whatever value is consistent with the prevailing utility level, $\overline{V}$.

We can now formally define the equilibrium. An urban land-use equilibrium in a monocentric, circular, and open city with absentee landowners is a vector $(\overline{x}, N)$ such that (14) and (15) are satisfied.

Spillovers and Urban Sprawl

While an undervaluation of open space leads to urban sprawl and thus an expansion in $\overline{x}$, a decrease in aggregate housing improvements $\overline{I}$ may reduce urban sprawl.[13] Negative spillovers from urban decline decrease the value of residential land at the city boundary [left-hand side of (12)], thereby reducing the size of the city, $\overline{x}$.[14]

[12] Note that the improvements decision by a single landowner depends on the improvements of all other landowners. This interdependence of improvement choices implies that they form a Cournot-Nash equilibrium in which each landlord chooses an improvement level that is the best response to the improvements chosen by his neighbors. To ensure stability of the equilibrium, we assume

$$-1 \leq \frac{\partial I^*(x)}{\partial \overline{I}} \leq 1 .$$

Our model accommodates both strategic complementarities when

$$\frac{\partial I^*(x)}{\partial \overline{I}} > 0 ,$$

and congestion/repelling effects when

$$\frac{\partial I^*(x)}{\partial \overline{I}} < 0 .$$

Ioannides and Zabel (2003) and Ioannides (2002) provide evidence that neighbors' decisions to maintain, repair, renovate, or make additions to their home induce other individuals to increase their own repairs, maintenance, and renovations.

[13] Open space provides many potential public goods with aesthetic, recreation, and biodiversity values. It also offers associated ecosystem services such as flood control and water purification. Because the private land market does not recognize these public goods, the private cost of converting land from agriculture to residential use [the right-hand side of (12)] is lower than the social cost, leading to too much development at the fringe.

[14] In addition,

$$\frac{\partial r(y - t\overline{x}, O, \overline{I}, \overline{V})}{\partial \overline{I}} > 0$$

implies that housing improvements are underprovided from the perspective of residents at the city boundary, and would thus benefit from marginal increases in housing improvements. As a result, subsidies for

Given these two countervailing forces, the net effect on urban sprawl is ambiguous. If the market failure of undervaluation of open space is strong enough to overcome the negative spillovers from urban decline, sprawl occurs.

From a policy perspective, one implication of our results is that it may not be true that a policy aimed at reducing urban decline can decrease the size of a city. Furthermore, from (11) any anti-sprawl policy that saves open space at the urban boundary also influences housing improvements at the city core through bid rents, which in turn feed back into city size. Below, we further explore the implication of these spillover and feedback effects on the welfare effects of an anti-sprawl development tax.

The Welfare Effects of the Development Tax

Welfare Measurement

To calculate the efficiency impacts of a policy intervention, we note that prior to a policy intervention, total value of land in the city, R, is given by the total value of land in residential use plus total value of land in agriculture use:

$$R = \int_0^{\bar{x}} r(\cdot, x) 2\pi x dx + \int_{\bar{x}}^{\bar{m}} r_a 2\pi x dx , \qquad (16)$$

where $\bar{m}$ denotes the geographic extent of potentially developable land. The efficiency impacts of a policy are calculated as changes in the value of land resulting from the policy intervention net of any changes in government transfers.

housing improvements would provide benefits that span the metropolitan area. By contrast, if

$$\frac{\partial r(y - t\bar{x}, O, \bar{I}, \bar{V})}{\partial \bar{I}} < 0 ,$$

this would suggest that increases in housing improvements in the city center would reduce the demand for land near the city boundary. This would be consistent with competition between cities and suburbs for households, and would imply that subsidies for housing improvements reduce the demand for land in the suburbs. Finally, if

$$\frac{\partial r(y - t\bar{x}, O, \bar{I}, \bar{V})}{\partial \bar{I}} = 0 ,$$

suburban land values are independent of housing investments at the city center.

For the policies considered below, a development tax τ_D per unit of residential land is imposed. Such a tax will reduce the city boundary, curbing urban sprawl and increasing open space—formally, from (14),

$$\frac{dO}{d\tau_D} = -2\pi\bar{x}\frac{d\bar{x}}{d\tau_D} .$$

Development Tax with Revenues Returned Lump-Sum to All Landowners

First consider the welfare effects of a development tax τ_D with revenue returned lump-sum g to all landowners. The efficiency effects of a marginal increase in τ_D can be expressed as

$$\frac{dR}{d\tau_D} = \underbrace{\left[\int_0^{\bar{x}} \frac{\partial p}{\partial O} h(S) 2\pi x dx - \tau_D\right]\frac{dO}{d\tau_D}}_{W^P} + \underbrace{\int_0^{\bar{x}} \frac{\partial p}{\partial \bar{I}}\frac{d\bar{I}}{dO} h(S) 2\pi x dx \frac{dO}{d\tau_D}}_{W^I} \qquad (17)$$

(see appendix for derivation), where the change in open space can be further decomposed into

$$\frac{dO}{d\tau_D} = \frac{-2\pi\bar{x}\dfrac{\partial\bar{x}}{\partial\tau_D}}{1 + 2\pi\bar{x}(\dfrac{\partial\bar{x}}{\partial O} + \dfrac{\partial\bar{x}}{\partial\bar{I}}\dfrac{d\bar{I}}{dO})} . \qquad (18)$$

Equation (17) decomposes the welfare effect of the development tax into two main components. The term denoted W^P represents the traditional *Pigouvian welfare effect* associated with landowners responding to the development tax by reducing the amount of land developed at the boundary of the city. This effect equals the increase in open space multiplied by the wedge between the development tax and the marginal external benefit of open space. This term is analogous to the welfare effects derived in Bento, Franco, and Kaffine (2006) for a development tax or an urban growth boundary in the absence of urban decline.

In addition to this effect, an additional welfare gain occurs through the *aggregate improvements effect*, denoted W^I. By increasing open space provision, bid rents increase, which in turn increases private improvements. By the envelope theorem, private improvements disappear from the welfare formula; however, the benefits of aggregate improvements are capitalized into housing prices, generating the additional welfare effect. Note that this additional effect implies that the optimal development tax should be set higher than the Pigouvian level, and is (implicitly) given by

$$(19)\qquad \tau_D^* = \int_0^{\bar{x}} \left(\frac{\partial p}{\partial O} + \frac{\partial p}{\partial \bar{I}}\frac{d\bar{I}}{dO}\right) h(S) 2\pi x dx .$$

Although improvements generate an additional welfare effect, this effect implicitly depends on households' value of open space. As such, if households' valuation of open space is negligible, the optimal development tax will be equal to zero in the case of lump-sum returned revenues.

The presence of urban decline generates an additional effect, as shown in equation (18). By stimulating improvements, the policy can increase housing bid rents at the urban boundary, leading to a decrease in the level of open space generated by the development tax. This feedback from the mitigation of urban decline implies that a larger development tax is required to achieve a given reduction in suburban sprawl relative to the case where these feedbacks are absent.

Development Tax with Improvements Subsidy

Now consider the welfare effects of a development tax τ_D with revenues from this tax earmarked to fund subsidies g to improvements.[15] The efficiency effects of a marginal increase in τ_D can be expressed as

$$(20)\qquad \frac{dR}{d\tau_D} = \underbrace{\left[\int_0^{\bar{x}} \frac{\partial p}{\partial O} h(S) 2\pi x dx - \tau_D\right]\frac{dO}{d\tau_D}}_{W^P} + \underbrace{\int_0^{\bar{x}} \frac{\partial p}{\partial \bar{I}}\frac{\partial \bar{I}}{\partial O} h(S) 2\pi x dx \frac{dO}{d\tau_D}}_{W^I} + \underbrace{\int_0^{\bar{x}} \frac{\partial p}{\partial \bar{I}}\frac{\partial \bar{I}}{\partial g}\frac{dg}{d\tau_D} h(S) 2\pi x dx - g\frac{d\bar{I}}{d\tau_D}}_{W^R}$$

(see appendix for derivation), where the change in open space can be further decomposed into

$$(21)\qquad \frac{dO}{d\tau_D} = \frac{-2\pi\bar{x}\left(\frac{\partial \bar{x}}{\partial \tau_D} + \frac{\partial \bar{x}}{\partial \bar{I}}\frac{\partial \bar{I}}{\partial g}\frac{dg}{d\tau_D}\right)}{1 + 2\pi\bar{x}\left(\frac{\partial \bar{x}}{\partial O} + \frac{\partial \bar{x}}{\partial \bar{I}}\frac{d\bar{I}}{dO}\right)} .$$

Comparing equation (20) with (17), the development tax with revenues recycled to subsidize improvements exploits the same *Pigouvian welfare effect* W^P and *aggregate improvements effect* W^I channels as the case of a development tax with revenues returned lump-sum. However, an additional welfare effect appears in the form of the *revenue-recycling effect*, denoted W^R. This welfare channel represents the net welfare effect associated with recycling the revenues from the development tax to subsidize improvements. The first term represents the marginal social benefits of subsidized aggregate improvements capitalized into housing prices. The second term is simply the cost of improvements.

Thus, if the marginal social benefits of improvements exceed the marginal cost, that is,

$$\int_0^{\bar{x}} \frac{\partial p}{\partial \bar{I}}\frac{\partial \bar{I}}{\partial g}\frac{dg}{d\tau_D} h(S) 2\pi x dx > g\frac{d\bar{I}}{d\tau_D} ,$$

revenues should be recycled. On the other hand, if

$$\int_0^{\bar{x}} \frac{\partial p}{\partial \bar{I}}\frac{\partial \bar{I}}{\partial g}\frac{dg}{d\tau_D} h(S) 2\pi x dx < g\frac{d\bar{I}}{d\tau_D} ,$$

revenues should be lump-sum returned. If the marginal social benefits of improvements do exceed the marginal cost, this also implies that the development tax should be set at a higher level to capture the revenue-recycling benefits associated with subsidizing improvements. The optimal tax in this case is (implicitly) given by

[15] A land tax (such as the development tax) is a logical source of revenue for urban policy, as it is less distortionary than other revenue sources such as a property tax (Bento, Franco, and Kaffine 2011). Considering development taxes and how development tax revenue is used is important, particularly when anti-sprawl objectives can be amplified or weakened via revenue-recycling.

(22)

$$\tau_D^* = \int_0^{\bar{x}} \left(\frac{\partial p}{\partial O} + \frac{\partial p}{\partial \bar{I}}\frac{d\bar{I}}{dO}\right) h(S) 2\pi x dx + \left[\int_0^{\bar{x}} \frac{\partial p}{\partial \bar{I}}\frac{\partial \bar{I}}{\partial g}\frac{dg}{d\tau_D} h(S) 2\pi x dx - g\frac{d\bar{I}}{d\tau_D}\right]\frac{d\tau_D}{dO}.$$

In contrast with lump-sum revenue recycling, when revenues are used to subsidize improvements, a positive development tax may be justified even if household valuation of open space is negligible. In other words, the development tax should be part of the optimal local tax system.

Finally, it should be noted that subsidizing improvements also affects suburban sprawl, as shown in equation (21). By allocating revenue to mitigate urban decline, bid rents throughout the city increase, increasing development pressure at the city boundary and resulting in less open space. Thus, when revenues are recycled through housing improvement subsidies, an even higher development tax would be required to achieve a given reduction in suburban sprawl. Note that equation (21) raises the possibility that the city boundary could *increase* when revenues are recycled (or equivalently, that open space could decrease). Such a scenario may even be optimal relative to the lump sum return if the *revenue-recycling effect* W^R is substantially larger than the (in this case, negative) *Pigouvian welfare effect* W^P and *aggregate improvements effect* W^I.

Conclusions

This paper examines the welfare effects of development taxes aimed at curbing sprawl in the presence of urban decline at the city core. A central theme of the paper is that there are potential additional efficiency effects from introducing the development tax that come from feedbacks between urban decline and suburban sprawl, as well as the mechanism of recycling the revenues from the development tax. In particular, comparisons are made between two forms of revenue recycling: using the revenues of development taxes to return them in a lump-sum fashion to all landowners, and using the revenues of the development tax to finance a subsidy to improvements.

When the revenues from the development tax are returned lump-sum, two welfare channels emerge: the traditional *Pigouvian welfare effect*, corresponding to the net benefits from increasing open space, and the *aggregate improvement effect,* which represents the efficiency gain associated with the capitalization resulting from the mitigation of urban decline. When development tax revenues are recycled in the form of improvement subsidies, an additional welfare channel emerges: the *revenue-recycling effect*, which is the additional welfare change arising from capitalization of subsidized improvements. As a result of the *aggregate improvement effect* and *revenue-recycling effect,* the optimal development tax should be set higher than the Pigouvian level. In fact, when revenues are recycled as a subsidy for housing improvements, a positive development tax may still be justified even when household valuation of open space is negligible.

Importantly, feedbacks between anti-sprawl policies and urban decline can also affect the level of suburban sprawl. Achieving a given reduction in suburban sprawl requires a larger development tax than the case where these feedback effects are absent, and these feedback effects are exacerbated when revenues are recycled. In fact, suburban sprawl may even *increase* when revenues are recycled. Policymakers interested in curbing sprawl should be mindful of these potential feedbacks in the urban system when setting anti-sprawl policy.

An important caveat of the framework developed in this paper deserves mention. While our theory suggests that population responds to a city's amenities and disamenities, our framework ignores reverse causation. It overlooks the possibility that urban amenities and disamenities are a consequence rather than a cause of the location of households within an urban economy. In recent work, Brueckner and Helsley (2011) develop a duocentric closed linear city model in which suburban areas and the city core compete for mobile residents to show that market failures that reduce the cost of occupying suburban areas also reduce central-city housing prices leading to deficient levels of central-city reinvestment. As a result, blight reduction can be a beneficial byproduct of anti-sprawl policies to the extent that these policies shift population towards the city center, improving maintenance incentives. Integrating the effects of our study with the effects found in Brueckner and Helsley (2011) into a unified framework is certainly a productive direction for future research.

References

Albouy, D. 2008. "Are Big Cities Bad Places to Live? Estimating Quality of Life Across Metropolitan Areas." NBER Working Paper No. 14472, National Bureau of Economic Research, Cambridge, MA.

Anas, A., and H. Rhee. 2006. "Curbing Excess Sprawl with Congestion Tolls and Urban Boundaries." *Regional Science and Urban Economics* 36(4): 510–541.

Anderson, S.T., and S.E. West. 2006. "Open Space, Residential Property Values, and Spatial Context." *Regional Science and Urban Economics* 36(6): 773–789.

Banzhaf, H.S., and N. Lavery. 2010. "Can the Land Tax Help Curb Urban Sprawl? Evidence from Growth Patterns in Pennsylvania." *Journal of Urban Economics* 67(2): 169–179.

Bento, A.M., M. Cropper, M. Mobarak, and K. Vinha. 2005. "The Impact of Urban Spatial Structure on Travel Demand in the United States." *Review of Economics and Statistics* 87(3): 466–478.

Bento, A.M., S.F. Franco, and D. Kaffine. 2006. "The Efficiency and Distributional Impacts of Alternative Anti-Sprawl Policies." *Journal of Urban Economics* 59(1): 121–141.

____. 2009. "Efficiency and Spatial Impacts of Development Taxes: The Critical Role of Alternative Revenue-Recycling Schemes." *American Journal of Agricultural Economics* 91(5): 1304–1311.

____. 2011. "Is There a Double-Dividend from Anti-Sprawl Policies?" *Journal of Environmental Economics and Management* 61(2): 135–152.

Brueckner, J.K. 2000. "Urban Sprawl: Diagnosis and Remedies." *International Regional Science Review* 23(2): 160–171.

____. 2001. "Urban Sprawl: Lessons from Urban Economics." In W.G. Gale and J.R. Pack, eds., *Brookings-Wharton Papers on Urban Affairs*. Washington, D.C.: Brookings Institution Press.

____. 2007. "Urban Growth Boundaries: An Effective Second Best Remedy for Unpriced Traffic Congestion?" *Journal of Housing Economics* 76(3/4): 263–274.

Brueckner, J.K., and R.W. Helsley. 2011. "Sprawl and Blight." *Journal of Urban Economics* 69(2): 205–213.

Brueckner, J.K., and A.G. Largey. 2008. "Social Interaction and Urban Sprawl." *Journal of Urban Economics* 64(1): 18–34.

Burchfield, M., H.G. Overman, D. Puga, and M.A. Turner. 2006. "Causes of Sprawl: A Portrait from Space." *Quarterly Journal of Economics* 121(2): 587–633.

Cheshire, P.C., and S.C. Sheppard. 2002. "The Welfare Economics of Land Use Planning." *Journal of Urban Economics* 52(2): 242–269.

____. 2003. "Taxes versus Regulation: The Welfare Impacts of Policies for Containing Urban Sprawl." In D. Netzer, ed., *The Property Tax, Land Use and Land Use Regulation*. Cheltenham: Edward Elgar.

Eid, J., H.G. Overman, D. Puga, and M.A. Turner. 2008. "Fat City: Questioning the Relationship Between Urban Sprawl and Obesity." *Journal of Urban Economics* 63(2): 385–404.

Ellen, I.G., M.H. Schill, A.E. Schwartz, and I. Voicu. 2003. "Housing Production Subsidies and Neighborhood Revitalization: New York City's Ten Year Capital Plan for Housing." *Federal Reserve Bank of New York Economic Policy Review* 9(2): 71–85.

Geoghegan, J. 2002. "The Value of Open Spaces in Residential Land Use." *Land Use Policy* 19(1): 91–98.

Geoghegan, J., L. Lynch, and S. Bucholtz. 2003. "Capitalization of Open Spaces into Housing Values and the Residential Property Tax Revenue Impacts of Agricultural Easement Programs." *Agricultural and Resource Economics Review* 32(1): 33–46.

Glaeser, E., and J. Gyourko. 2005. "Urban Decline and Durable Housing." *Journal of Political Economy* 113(2): 345–375.

Glaeser, E., and M. Khan. 2004. "Sprawl and Urban Growth." In J.V. Henderson and J.F. Thisse, eds., *Handbook of Urban and Regional Economics* (Vol. IV). Oxford: Oxford University Press.

Gyourko, J., and A. Saiz. 2003. "Urban Decline and Housing Reinvestment: The Role of Construction Costs and the Supply Side." Federal Reserve Bank of Philadelphia Working Paper No. 03-9.

Ioannides, Y.M. 2002. "Residential Neighborhood Effects." *Regional Science and Urban Economics* 32(2): 145–165.

Ioannides, Y.M., and J.E. Zabel. 2003. "Neighborhood Effects and Housing Demand." *Journal of Applied Econometrics* 18(5): 563–584.

Irwin, E. 2002. "The Effects of Open Space on Residential Property Values." *Land Economics* 78(4): 465–480.

Irwin, E., and N. Bockstael. 2007. "The Evolution of Urban Sprawl: Evidence of Spatial Heterogeneity and Increasing Land Fragmentation." *Proceedings of the National Academy of Sciences* 104(52): 20672–20677.

Kutty, N.K. 1995. "A Dynamic Model of Landlord Reinvestment Behavior." *Journal of Urban Economics* 37(2): 212–237.

McConnell, V., and M. Walls. 2005. "The Value of Open Space: Evidence from Studies of Nonmarket Benefits." Resources for the Future, Washington, D.C.

Nechyba, T., and R. Walsh. 2004. "Urban Sprawl." *Journal of Economic Perspectives* 18(4): 177–200.

Plantinga, A., and S. Bernell. 2007. "The Association Between Urban Sprawl and Obesity: Is It a Two-Way Street?" *Journal of Regional Science* 47(5): 857–879.

Rossi-Hansberg, E., P. Sarte, and R. Owens. 2009. "Housing Externalities." NBER Working Paper No. 14369, National Bureau of Economic Research, Cambridge, MA.

Santiago, A.G., G. Galster, and P. Tatian. 2001. "Assessing the Property Value Impacts of the Dispersed Housing Subsidy Program in Denver." *Journal of Policy Analysis and Management* 20(1): 65–88.

Schwartz, A.E., I.G. Ellen, I. Voicu, and M.E. Schill. 2006. "The External Effects of Place Based Subsidized Housing." *Regional Science and Urban Economics* 36(6): 679–707.

Wu, J. 2006. "Environmental Amenities, Urban Sprawl and Community Characteristics." *Journal of Environmental Economics and Management* 52(2): 527–547.

Wu, J., and A. Plantinga. 2003. "The Influence of Public Open Space Policies on Urban Spatial Structure." *Journal of Environmental Economics and Management* 46(2): 288–309.

Appendix: Mathematical Derivations of Key Equations

Deriving Equation (17)

Consider a development tax τ_D with revenue returned lump-sum g to all landowners. Total rents are given by

$$\text{(A1)} \quad R(\tau_D) = \int_0^{\bar{x}} [ph(S) - C^S(S) - C^I(I,S)]2\pi x dx + \int_{\bar{x}}^{\bar{m}} r_a 2\pi x dx - \int_0^{\bar{x}} \tau_D 2\pi x dx + \int_0^{\bar{m}} g 2\pi x dx.$$

The government budget constraint satisfies

$$\text{(A2)} \quad \int_0^{\bar{m}} g 2\pi x dx = t_D \bar{x}_{t_D}^2 .$$

From equation (10), the first-order conditions for landowners are given by

$$\text{(A3)} \quad r_S = p\frac{dh}{dS} - \frac{dC^S}{dS} - \frac{\partial C^I}{\partial S} = 0$$
$$r_I = \frac{\partial p}{\partial I} h(S) - \frac{\partial C^I}{\partial I} = 0.$$

By setting (10) evaluated at $x = \bar{x}$ equal to the agricultural rent, we derive

$$\text{(A4)} \quad r(\bar{x}) - \tau_D = r_a .$$

Differentiating the city total aggregated land value (A1) with respect to τ_D while taking into account (A2)–(A4) yields the efficiency effects of a lump-sum development tax, expressed as equation (17).

Deriving Equation (18)

From (13) and (A4), the total derivative of $\bar{x}$ is given by

$$\text{(A5)} \quad \frac{d\bar{x}}{d\tau_D} = \frac{\partial \bar{x}}{\partial \tau_D} + \frac{\partial \bar{x}}{\partial O}\frac{dO}{d\tau_D} + \frac{\partial \bar{x}}{\partial \bar{I}}\frac{d\bar{I}}{dO}\frac{dO}{d\tau_D}$$
$$= \frac{\partial \bar{x}}{\partial \tau_D} + (\frac{\partial \bar{x}}{\partial O} + \frac{\partial \bar{x}}{\partial \bar{I}}\frac{d\bar{I}}{dO})(-2\pi\bar{x}\frac{d\bar{x}}{d\tau_D}).$$

Noting that

$$\frac{dO}{dt_D} = -2\pi\bar{x}\frac{d\bar{x}}{dt_D} ,$$

rearranging (A5) and solving yields equation (18).

Deriving Equation (20)

Consider a development tax τ_D with revenues recycled as a subsidy g per unit of improvements. Total rents are given by

$$\text{(A6)} \quad R(\tau_D) = \int_0^{\bar{x}} [ph(S) - C^S(S) - C^I(I,S) + gI]2\pi x dx + \int_{\bar{x}}^{\bar{m}} r_a 2\pi x dx - \int_0^{\bar{x}} \tau_D 2\pi x dx.$$

The government budget constraint satisfies

$$\text{(A7)} \quad g\bar{I} = t_D \bar{x}_{t_D}^2 .$$

Modifying equation (10), the first-order conditions for landowners are given by

$$\text{(A8)} \quad r_S = p\frac{dh}{dS} - \frac{dC^S}{dS} - \frac{\partial C^I}{\partial S} = 0$$
$$r_I = \frac{\partial p}{\partial I} h(S) - \frac{\partial C^I}{\partial I} + g = 0.$$

Differentiating the city total aggregated land value (A6) with respect to τ_D while taking into account (A4), (A7), and (A8) yields the efficiency effects of a development tax with revenues recycled into improvement subsidies, as expressed in equation (20).

Deriving Equation (21)

From (13) and (A4), the total derivative of $\bar{x}$ is given by

(A9)

$$\frac{d\bar{x}}{d\tau_D} = \frac{\partial \bar{x}}{\partial \tau_D} + \frac{\partial \bar{x}}{\partial O}\frac{dO}{d\tau_D} + \frac{\partial \bar{x}}{\partial \bar{I}}\left(\frac{\partial \bar{I}}{\partial O}\frac{dO}{d\tau_D} + \frac{\partial \bar{I}}{\partial g}\frac{dg}{d\tau_D}\right)$$
$$= \frac{\partial \bar{x}}{\partial \tau_D} + \frac{\partial \bar{x}}{\partial \bar{I}}\frac{\partial \bar{I}}{\partial g}\frac{dg}{d\tau_D}$$
$$+\left(\frac{\partial \bar{x}}{\partial O} + \frac{\partial \bar{x}}{\partial \bar{I}}\frac{d\bar{I}}{dO}\right)\left(-2\pi\bar{x}\frac{d\bar{x}}{d\tau_D}\right).$$

Noting that

$$\frac{dO}{dt_D} = -2\pi\bar{x}\frac{d\bar{x}}{dt_D},$$

rearranging (A9) and solving yields equation (21).