Relative Tax Burdens, Suburbanization, and the

Efficiency of Local Public Good Provision

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I. Introduction

In this paper, I present a model of resident location choice and local public good provision that explores the effect of a city's taxes on suburbanization and the efficiency of local public good provision. The central city provides a pure public good to benefit its own residents. However, this public good is consumed by both city and suburban residents. City residents pay taxes for the public good and suburban residents pay commuting costs to consume the public good. Residents compare these taxes and commuting costs when choosing where to live. I show that local public good provision creates an incentive to suburbanize and free-ride on city amenities; this incentive leads to an inefficient under-provision of local public goods.

A well known flaw of Tiebout's (1956) model of local public good provision is his failure to account for the positive externalities associated with local public good provision. The non-excludability of many local public goods (like roads, parks, and public safety) allows consumption by both residents and non-residents. This reality contradicts the "no spillovers" assumption of Tiebout's model. Since Tiebout's seminal paper, many studies have considered the effect of these positive spillovers on the efficiency of local public good provision. These studies generally show that positive spillovers lead to an under-provision of local public goods (Pauly, 1970; Sandler, 1975); however, not many of these studies account specifically for the interaction between a central city and a suburb. Dur and Staal (2007) consider a city and suburb in their model but fail to account for resident mobility. By including resident mobility, I am able to consider how local public good provision affects population distribution. I can also consider the effect of transportation policy on social welfare.

The mechanism driving suburbanization in my model was confirmed in an empirical study by Bradford and Kelejian (1973). Specifically, Bradford and Kelejian found that tax differences between a city and suburb are statistically significant in explaining suburbanization. Mieszkowski and Mills

(2003, pp. 145-46) contemplate the social welfare implications of this significant relationship. They argue that if a resident is indifferent between living in the city or the suburb, by choosing the suburb, the resident trades off the relatively higher taxes of the city for commuting costs. If the resident locates in the city, (s)he contributes to taxes which contributes to public good provision. Conversely, if the resident locates in the suburbs, that potential tax money is spent on commuting costs and is wasted. Therefore, Miezskowski and Mills argue that suburbanization leads to a decrease in both local public good provision and social welfare. Although the link between relative taxes and suburbanization was described thoroughly in their paper, how this link relates to social welfare seemed an informal afterthought. To my knowledge, no model has been created to consider the validity of this hypothesis.

In my model's equilibrium, the city provides a level of public good that maximizes the utility of its own residents. Residents trade off between the resulting city taxes and suburban commuting costs when deciding where to locate. In the comparative statics section of my paper, I derive the formulas for the equilibrium population distribution. Interestingly, relative suburban population increases with income. Although the underlying mechanism may be different, this relationship is common in real cities. Furthermore, my model provides an initially counter-intuitive result. As residents value the public good more relative to disposable income, the suburbs expand. Lastly, increasing the road capacity into the city leads to a larger equilibrium suburban population. The social optimum in my model occurs when all residents locate in the city. Suburbanization diminishes social welfare by decreasing public good provision and by increasing the social resources wasted on commuting.

In the policy section, I consider the effect of four different policies on my model's equilibrium. First, I consider how changing the road capacity into a city affects suburbanization and, consequently, social welfare. Supporting previous transportation literature (Arnott & Small, 1994), I find that increasing the road capacity into a city does not decrease per-capita commuting costs in the long-run.

However, due to increasing suburban population, this capacity increase does increase total commuting costs which diminishes social welfare. Second, I consider how commuting tolls affect social welfare. I find that commuting tolls decrease equilibrium suburban population by both increasing suburban commuting costs and decreasing city taxes. Also, a commuting toll can affect road congestion where a change in road capacity cannot. Third, I explore the effect of a commuter tax on social welfare. A commuter tax is defined as an income tax on non-resident workers. In practice, commuter taxes are set lower than city taxes. In my model, if the commuter tax is set lower than per-capita city taxes, social welfare will improve but the social optimum will not be reached. Last, I consider amalgamation which does lead to the social optimum. However, if I remove the assumption of costless resident mobility, I find that suburban residents may not agree to amalgamate in equilibrium. This result reflects the findings of Dur and Staal (2007) and Calabrese et al. (2002).

II. Literature Review

My paper contributes to the literature by considering the efficiency of local public good provision within the context of suburbanization and transportation policy. However, the literature considering the causes of suburbanization is vast. In "Causes of Metropolitan Suburbanization," Mieszkowski and Mills help condense this literature by presenting two widely recognized theories of decentralization. These two theories are the "natural evolution" theory and the "flight from blight" theory. The "natural evolution" theory regards rising incomes, decreasing transportation costs, and increasing city density as the primary causes of suburbanization. Conversely, the "flight from blight" theory considers the problems inherent to cities as the driving force of suburbanization. These problems include excessive crime, poverty, congestion, and taxes. Because taxes are related to public good provision, I chose to model the effect of the relative taxes between a city and suburb on suburbanization and, consequently, the efficiency of local public good provision.

My model shows that the tax difference between a city and suburb exacerbates the under-provision of local public goods through suburbanization. Holtmann (1968) reflects this result with a quote relating to suburbanization: “While this movement away from the country's cities no doubt increases the welfare of the migrants, it often leaves those that are left behind worse off... If the city has an income tax that either doesn't apply to nonresidents or which taxes nonresidents at a lower rate, then, the city's revenues are cut directly.” This resulting decrease in tax revenue necessitates a lower provision of public goods. Mieszkowski and Mills (2003) attribute this loss of public good provision to a particular tradeoff: “The loss in output may be largely the higher commuting costs associated with suburban residence. Households trade off higher commuting costs against the higher taxes and lower service levels at central locations.”

Another important aspect of my model is the relationship between commuting costs and suburbanization. In this way, my model also contributes to the literature by considering the indirect effect of transportation policy on local public good provision and social welfare. Commuting costs, which are affected by road congestion, are an important determinant of suburbanization. When road congestion intensifies, suburban residents often push for increased road capacity. Arnott and Small (1994) describe the difficulty of addressing traffic congestion in this way. An increase in road capacity will decrease the commuting costs for suburban residents in the short-run. However, this decrease in commuting costs makes it relatively cheaper to live in the suburbs. This change suburban living costs will induce migration into the suburbs which offsets the initial purpose of the policy. Studies have shown that increasing road capacity can actually lead to increased commuting costs in the long-run (Arnott & Small, 1994).

Until 1990, resident location choice models neglected the link between traffic congestion and resident location choice. Yun (1990) created a spatial model of resident location choice to consider this link. The results I find between commuting costs and suburbanization coincide with Yun's. However, in Yun's model, road congestion is exogenously determined, and public good provision is not considered. In my model, I endogenize traffic congestion by considering the interaction between road capacity and suburban population.

III. Model

I create a resident location choice model with a region that consists of a city and suburban municipality. There are two kinds of agents in my model – the city and homogeneous residents[1]. The city supplies a quantity of pure public good that maximizes the utility of its own residents. Public safety and city beautification could be examples of the public good provided in my model because they are reasonably non-rivalrous and non-excludable. I assume that both city and suburban residents consume the public good provided by the city. My model is spatially binary and does not account for distance within either municipality[2]. For simplicity, I assume the suburb provides no public good[3].

Residents locate in the municipality that maximizes their individual utility. I make the strong assumption that residents can costlessly relocate between municipalities[4]. Total resident population is represented by N. Total resident population is the sum of city and suburban populations which are represented by n_1 and n_2 accordingly. I set N=1 making both n_1 and n_2 fractions (between 0 and 1) that sum to 1[5]. All residents have the following Cobb-Douglas utility function:

(1) $u=\alpha \cdot \ln(G)+\ln(y-t-c)$

Resident utility is affected by both public good provision and disposable income[6]. G represents the total provision of public good by the city. Because the public good is non-rivalrous, G also

1 In the flight from blight theory, heterogeneous resident income serves to exacerbate the role of relative tax-burdens on suburbanization. By using homogenous residents in my model, any relationship between tax-burdens and suburbanization should be smaller than with heterogeneous income; therefore, this unrealistic simplification should serve to strengthen the results of my model.

2 In the literature, resident location choice models commonly consider distance. In contrast, my current model does not.

3 The qualitative results of my model would not change with suburban public good provision. This is discussed further in the conclusion of the paper.

4 This assumption does not adversely affect the outcome of my model except when considering amalgamation. I relax this assumption in the amalgamation portion of the policy section.

5 This allows me to consider n_1 and n_2 as percentages of total population by multiplying them by 100

6 Both the public good and disposable income are normal goods that exhibit diminishing marginal utility.

represents the quantity of public good available to each resident[7]. $(y-t-c)$ represents a resident's disposable income where y is a resident's income[8], t is the per-capita city tax, and c is the per-capita commuting costs. α represents a resident's relative valuation of the public good compared to disposable income.

The factors affecting a resident's disposable income depend on the municipality they locate in. The utility function for a city resident is represented by equation (2).

(2) $u_1=\alpha\cdot\ln(G)+\ln(y-t)$

Notice that city residents pay taxes but not commuting costs. Total city taxes are equal to the total cost of providing the public good. I assume that each city resident pays an equal portion of the total taxes; therefore, per-capita taxes are represented by $t=(P_g\cdot G)/n_1$. P_g represents the cost of providing one unit of public good. For simplicity, I assume that $P_g=1$. All else equal, per-capita city taxes increase with public good provision and decrease with city population.

Equation (3) represents the utility function for a suburban resident.

(3) $u_2=\alpha\cdot\ln(G)+\ln(y-c)$

I assume that suburban residents must incur commuting costs to consume the public good[9]. In my model, commuting costs result from both road congestion and commuter tolls. Therefore, per-capita commuting costs are represented by $c=n_2^{\delta}+\theta$, where n_2^{δ} represents road congestion costs[10] (where δ represents the road capacity into the city) and θ represents the level of commuter tolls. Until the transportation policy section, I omit commuter tolls and assume that $c=n_2^{\delta}$. If suburban population is

7 I had initially considered the case of a congestible public good; however, my model specification caused the rivalry term to drop out when deriving the equilibrium public good provision.
8 Income is exogenously determined in my model
9 I could also assume that all suburban residents must commute to jobs in the city where they consequently benefit from city amenities. In reality, many suburban residents do regularly commute into cities because the majority of high-paying jobs are usually located there
10 Because n_2 cannot exceed 1 (with N=1), road congestion costs also cannot exceed 1.

fixed, an increase in road capacity (δ) decreases road congestion (and, consequently, commuting costs)[11]. Conversely, if road capacity is fixed, an increase in suburban population increases road congestion (and, consequently, commuting costs).

IV. Equilibrium

The equilibrium occurs when residents have no incentive to relocate. This occurs when $u_1 = u_2$ and residents benefit equally from living in the city or suburb. $u_1 = u_2$ is simplified to $t = c$ which represents the equilibrium condition. Therefore, in equilibrium, taxes must be equal to commuting costs. I will provide two examples to describe the mechanism that leads to equilibrium. First, if per-capita city taxes are greater than commuting costs, city residents move to the suburb where they increase their disposable income. This movement occurs until road congestion has increased enough to regain equilibrium. Second, if commuting costs are greater than per-capita city taxes, suburban residents move into the city where their disposable income is greater. As suburban population decreases, road congestion decreases until $t = c$ and equilibrium is reattained. Interestingly, it is per-capita commuting costs (and not taxes) that change with migration to regain equilibrium. This will be made more clear in the comparative statics portion of the paper. By substituting the equations for city taxes and commuting costs into the equilibrium condition, the following formula results:

(4) $$\frac{\hat{G}}{\hat{n1}} = \hat{n2}^{\delta}$$

Equation (4) can be used to find the equilibrium population distribution. However, since population distribution depends on the level of public good provision, I must first determine the provision of public goods in equilibrium. Recall that the city's objective is to provide the level of public good that maximizes the utility of its own residents. I can represent this objective by taking the derivative of u_1 with respect to G. Solving the resulting first order condition for $\hat{G}$ results in:

11 Remember that n_2 is a fraction between 0 and 1

(5) $\hat{G}=\dfrac{\alpha\cdot y\cdot n_1}{1+\alpha}$

Equation (5) shows that, all else equal, equilibrium public good provision increases with α, y, and n_1. Equilibrium population distribution can now be determined by substituting equation (5) into equation (4). The resulting equation can be solved for equilibrium suburban population[12]:

(6) $\hat{n}_2=(\dfrac{\alpha\cdot y}{1+\alpha})^{(\frac{1}{\delta})}$

Since $N=n_1+n_2$, with N normalized to 1, equilibrium city population is:

(7) $\hat{n}_1=1-(\dfrac{\alpha\cdot y}{1+\alpha})^{(\frac{1}{\delta})}$

V. Comparative Statics

In equilibrium, population distribution can only be changed by altering the relative cost of living between the city and suburb. In my model, this occurs through changes in per-capita taxes or commuting costs. Equation (6) and (7) show that equilibrium population distribution is affected by y, α, and δ. However, these variables specifically affect the population distribution by changing taxes or commuting costs. Changes to α and y affect per-capita taxes by causing the city to change how much public good it provides for *each resident*. For example, if resident income increases, the city will provide more public good for each resident. With this higher per-capita provision, the city must necessarily charge a higher per-capita tax to cover costs. Alternatively, changing road capacity into the city (δ) affects population distribution by changing per-capita commuting costs.

Equation (8) shows a positive relationship between alpha and equilibrium suburban population.

(8) $\dfrac{\partial n_2}{\partial \alpha}=\dfrac{(\dfrac{\alpha\cdot y}{1+\alpha})^{(\frac{1}{\delta})}}{(1+\alpha)\delta\cdot\alpha}>0$

12 Where $0 < y < [(\alpha+1)/\alpha]$, which ensures that $\hat{n}_2$ does not exceed 1 (which is impossible with N normalized to 1)

This relationship may initially seem counter-intuitive: Since the public good is located in the city, one might expect that more residents would move to the city as residents come to prefer the public good. However, remember that suburban residents may also consume the public good. So, as city residents value the public good more, the city provides more public good for each city resident. This leads to higher per-capita taxes which causes migration to the suburbs.

(9) $$\frac{\partial n_2}{\partial y}=\frac{\left(\frac{\alpha\cdot y}{1+\alpha}\right)^{\left(\frac{1}{\delta}\right)}}{\delta\cdot y}>0$$

Equation (9) shows a positive relationship between income and equilibrium suburban population. This relationship has also been observed historically in cities – consider the natural evolution theory of decentralization by Mieszkowski and Mills (2003); however, the mechanism providing this relationship in my model is not necessarily the most important one observed in the real world. In my model, as city residents become more wealthy they demand a higher provision of public good. This leads to a higher provision of public good for *each* city resident which increases per-capita taxes. Consequently, city residents migrate to the suburbs until increasing road congestion reinstates the equilibrium.

(10) $$\frac{\partial n_2}{\partial \delta}=\frac{-\left(\frac{\alpha\cdot y}{1+\alpha}\right)^{\left(\frac{1}{\delta}\right)}\cdot\ln\left(\frac{\alpha\cdot y}{1+\alpha}\right)}{\delta^2}>0$$

Lastly, equation (10) describes a positive relationship between δ and suburban population[13]. An increase in road capacity (for a given suburban population) decreases per-capita commuting costs. This decreases the relative cost of suburban living which causes city residents to migrate to the suburbs. Since δ has no effect on per-capita taxes, a change in δ will cause a shift in population distribution that

13 Due to the restriction on y (see footnote 12), $\ln\left(\frac{\alpha\cdot y}{1+\alpha}\right)<0$. Therefore, this restriction leads to the overall positive relationship between suburban population and road capacity in equilibrium.

will perfectly offset the initial change in per-capita commuting costs. In other words, in equilibrium, changing road capacity has no effect on per-capita commuting costs. This outcome is consistent with the findings of Arnott and Small (1994). Although per-capita commuting costs are not changed by δ, total commuting costs are. This relationship between δ and total commuting costs has important welfare considerations which I will discuss in the next section.

VI. Welfare Considerations

In my model, the social optimum occurs when all residents locate in the city[14]. In this case, no social resources are wasted on commuting and the city considers *all* residents when making its public good provision decision. However, each resident's choice to maximize their individual utility leads to suburban migration and a socially sub-optimal outcome. So, although an individual resident benefits from moving to the suburb and avoiding the city's tax, that resident's migration leads to a decrease in public good provision which causes an overall decrease in social welfare. To confirm this hypothesis, I created formula (11) to represent dead-weight loss.

(11) $$DWL = N \cdot u_1 - (\hat{n}_1 \cdot \hat{u}_1 + \hat{n}_2 \cdot \hat{u}_2)$$

This formula takes total resident utility in the social optimum and subtracts total resident utility in equilibrium. Equation (12) is created by substituting the formulas for $\hat{n}_1$, $\hat{n}_2$, $\hat{u}_1$, $\hat{u}_2$, and u_1 into equation (11) and simplifying.

(12) $$DWL = \alpha\left[\ln\left(\frac{\alpha \cdot y}{1+\alpha}\right) - \ln\left(-\frac{\alpha \cdot y\left[\left(\frac{\alpha \cdot y}{1+\alpha}\right)^{\left(\frac{1}{\delta}\right)} - 1\right]}{1+\alpha}\right)\right]$$

Equation (12) allows me to consider how deadweight loss changes with respect to y, α, and δ. Because the derivatives of DWL with respect to these variables are large and complicated, they fail to

14 In real metropolitan areas it is extremely unlikely that the social optimum will occur when all residents crowd into the central city. My model provides this social optimum because it lacks a housing market. I discuss the implications of adding a housing market in my paper's conclusion.

provide useful intuition. For this reason, I chose not to present comparative statics on deadweight loss mathematically. Instead, I present graphs in the appendix to illustrate the relationships between y, α, and δ and deadweight loss. From these graphs, you can discern the following relationships[15]:

(13) $\frac{\partial DWL}{\partial \alpha} > 0$

(14) $\frac{\partial DWL}{\partial y} > 0$

(15) $\frac{\partial DWL}{\partial \delta} > 0$

Notice that deadweight loss exhibits the same relationships with y, α, and δ as equilibrium suburban population does. In other words, as predicted by Mieszkowski and Mills (2003), anything causing an increase in equilibrium suburban population also increases deadweight loss.

VII. Policy Implications

A) *Transportation Policy*

Using transportation policy, the social optimum of my model can be reached by removing the road into the city or charging a commuter toll greater than the per-capita city tax. Mathematically, this is accomplished by setting $\delta=0$ or by setting $\theta > t$. If the road capacity is decreased but not eliminated, social welfare will increase but the social optimum will not be reached. Similarly, if a commuting toll is implemented but is set lower than per-capita city taxes, social welfare will increase but not to the social optimum. Commuting tolls function differently than changing road capacity in two ways. First of all, if the city keeps the revenue from commuting tolls[16], the city now has a source of revenue from non-residents. This additional revenue allows the city to decrease the tax burden to its own residents. In this case, commuting tolls decrease the incentive to suburbanize in two ways: By decreasing city

15 Although I present these relationships only under one set of parameters for illustrative purposes, I have tested these relationships under a wide range of parameters.

16 Higher levels of government sometimes keep the revenue from commuting tolls

taxes and by increasing commuting costs. The other way commuting tolls differ from altering road capacity is regarding road congestion.

When traffic congestion intensifies, suburban commuters generally push for greater road capacity to reduce their commuting costs. However, as outlined by my model and supported by other transportation studies, this kind of policy has little effect on road congestion in the long run (Arnott & Small, 1994). Although they are politically challenging to implement, commuter tolls are the only way to effectively reduce road congestion in the long-run. My model shows that, as commuting tolls increase, residents migrate back into the city. Although per-capita commuting costs do not change, the portion of these commuting costs exacted through road congestion has. This is a more efficient outcome because now some of the commuting costs are going towards city revenue rather than being wasted through traffic congestion.

B) Commuter Taxes

A commuter tax is defined as an income tax on non-resident workers. Commuter taxes were used by New York until 1991 to combat budget difficulties. Several other American cities including Washington and Boston have considered using commuter taxes to address their budget crises. Historically, proposed commuter taxes have been lower than the taxes to city residents. This difference is argued for on the grounds of fairness since non-residents already pay some tax in their suburban municipalities and generally use fewer city amenities than city residents. However, my model shows that if the commuter tax is set in this way, some residents will remain in the suburbs and the social optimum will not be reached. The implementation of a commuter tax decreases the disposable income of suburban residents. Therefore, the equilibrium condition changes from $t = c$ to:

(16) $t = c + \phi \cdot t$

where ϕ represents what percentage of the city tax that the commuter tax is set to. Since commuting costs approach zero as the suburban population approaches zero, as long as the commuter tax is less than the city tax ($\phi < 1$), some residents will choose to remain in the suburb and the social optimum will not be reached. Of course, in reality, suburban residents pay taxes in their own municipality. Therefore, unless the commuter tax equals the difference between city and suburban tax burdens, the socially optimal outcome is unlikely to occur.

C) Amalgamation

One definition of amalgamation is the merging of two politically distinct municipalities. Amalgamation is a commonly proposed solution to inefficient local public good provision in the literature. Since it is generally assumed that municipalities do not consider the positive spillovers to non-residents when providing public goods, it is argued that amalgamation can be used to internalize these positive spillovers. Within the context of my model, under amalgamation I assume the newly formed municipality will charge equal taxes to city and suburban residents. This is represented by equation (16) when $\phi = 1$. In this case, all residents move into the city and the social optimum is reached.

With the current model, both city and suburban residents stand to benefit from amalgamation. This is because public good provision increases with each resident the local government “cares about.” So, assuming each resident has perfect information on their well-being before and after amalgamation (in equilibrium versus the social optimum), both city and suburban residents would vote in favour of amalgamation. However, in reality, suburban residents tend to fight amalgamation. Dur and Staal (2007) and Calabrese et al. (2002) consider public good provision by suburban municipalities in their models. In their models, amalgamation creates greater costs in terms of tax increases for suburban residents than benefits in terms of suburban public good provision. With the assumption of costless mobility, this would not cause a problem for suburban residents. If amalgamation makes living in the suburbs less worthwhile, residents will costlessly relocate to the city and everyone will be better off. However, in reality, there are very large costs associated with moving – particularly if you are a homeowner. If I revoke the unrealistic assumption of costless mobility in my model, suburban residents incur a cost to amalgamate. Unless the benefits of amalgamation exceed the costs of moving, suburban residents will refuse to amalgamate.

VIII. Conclusion

In this paper I presented a model of resident location choice within the context of varying tax-burdens, suburbanization, and local public good provision. Within the context of the model, the social optimum occurs when all residents locate in the city. I find that free-riding suburban residents cause an under-provision of local public goods by locating in the suburbs and avoiding the city's taxes. Road capacity into the city affects suburbanization incentives and, consequently, social welfare. My model shows that increasing road capacity does not affect road congestion or per-capita commuting costs. However, it does affect total commuting costs. This finding is consistent with long-run studies. Commuter tolls can be used to reach the social optimum if they are set greater than per-capita city taxes. Also, commuter tolls, unlike road capacity, can effectively decrease road congestion. If the city keeps the revenue from commuter tolls, it can be used to decrease the tax burden on city residents and, consequently, decrease the incentive towards suburbanization and free-riding. Like commuter tolls, I find that commuter taxes improve social welfare but fail to achieve the social optimum unless they exceed the per-capita city taxes. In my model, amalgamation leads to the social optimum and would be agreed upon in equilibrium; however, if the assumption of costless resident mobility were removed, it is possible that suburban residents would vote against amalgamation. This result is more consistent with previous studies.

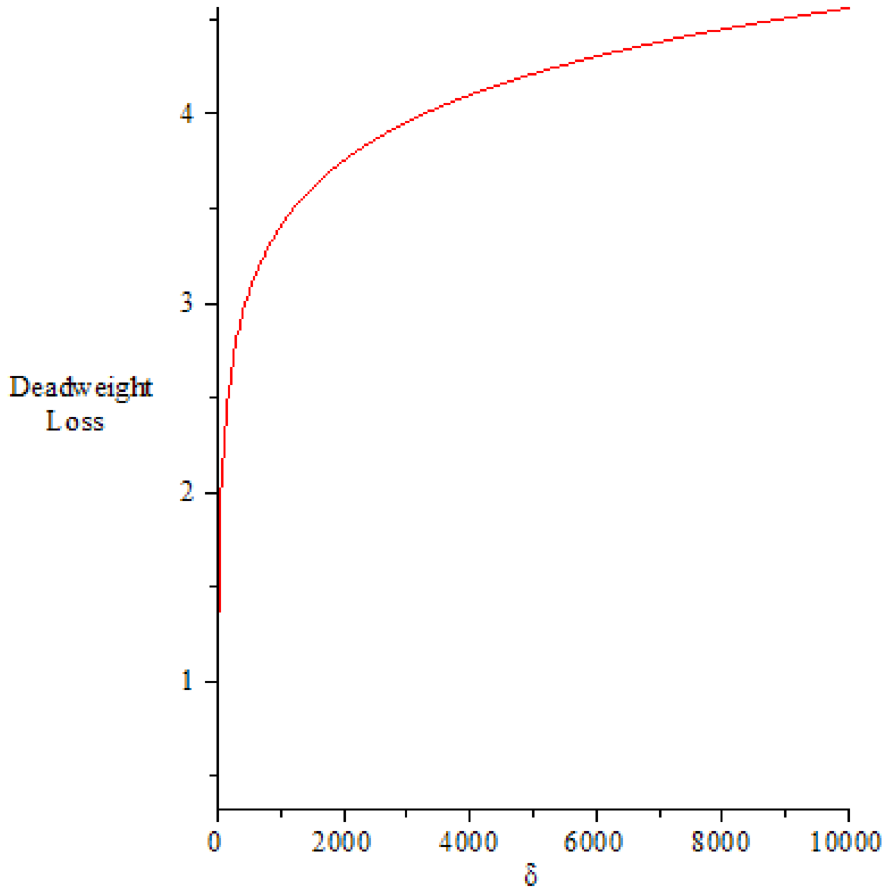
Disregarding suburban public good provision is an unrealistic assumption of my model. However, the qualitative results of my model are identical with or without suburban public good provision. If I allowed the suburb to provide a public good, it would provide a lower quantity than the city[17]. In this more complicated outcome, the suburban taxes would still be lower than the city's. Because it is the difference between the city and suburban taxes that lead to inefficiency, the qualitative results of my model do not change between the simple and complicated model.

Suburban public good provision aside, there are several modifications I believe will enhance the realism and scope of my model. My first priority is the inclusion of a housing market. Because land is fixed, per-capita housing rents would increase with municipal population. Therefore, with a housing market, a more realistic social optimum would occur with some residents locating in the suburb. A housing market would also increase the number of possible policy options. For example, I could consider the effects of municipal zoning restrictions and housing bylaws on resident location choice and public good provision.

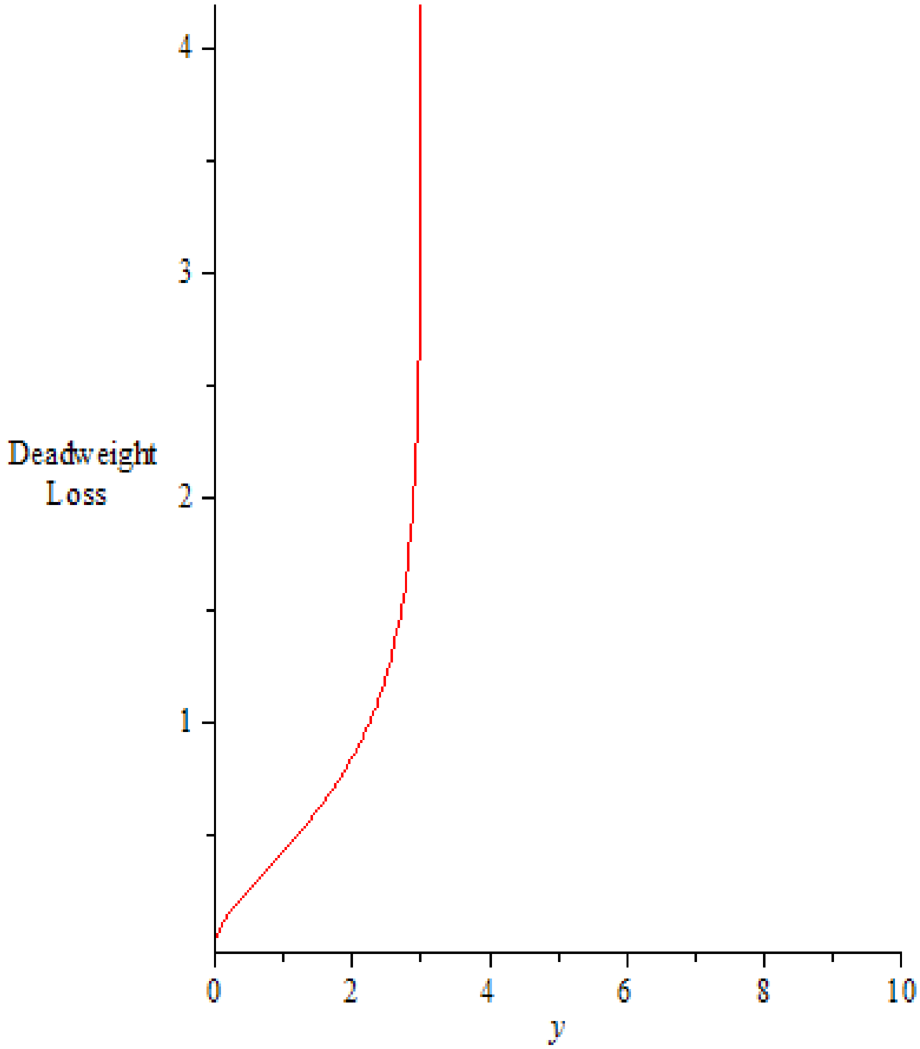
Secondly, I would like to consider modeling an excludable public good. This would allow the city to charge non-residents for using the public good. Since the city's prerogative is to maximize the utility of city residents, the city's current best strategy is to charge an infinite cost to non-residents; however, this outcome does not adequately reflect reality. If I allowed suburban residents to choose whether they commuted into the city or stayed in the suburb (where they would have access to a small quantity of public good), the city would be restricted in their pricing strategy. This restriction would allow me model an excludable public good in an interesting and realistic way.

17 The assumption that suburbs provide a lower quantity of public goods than the central city is realistic

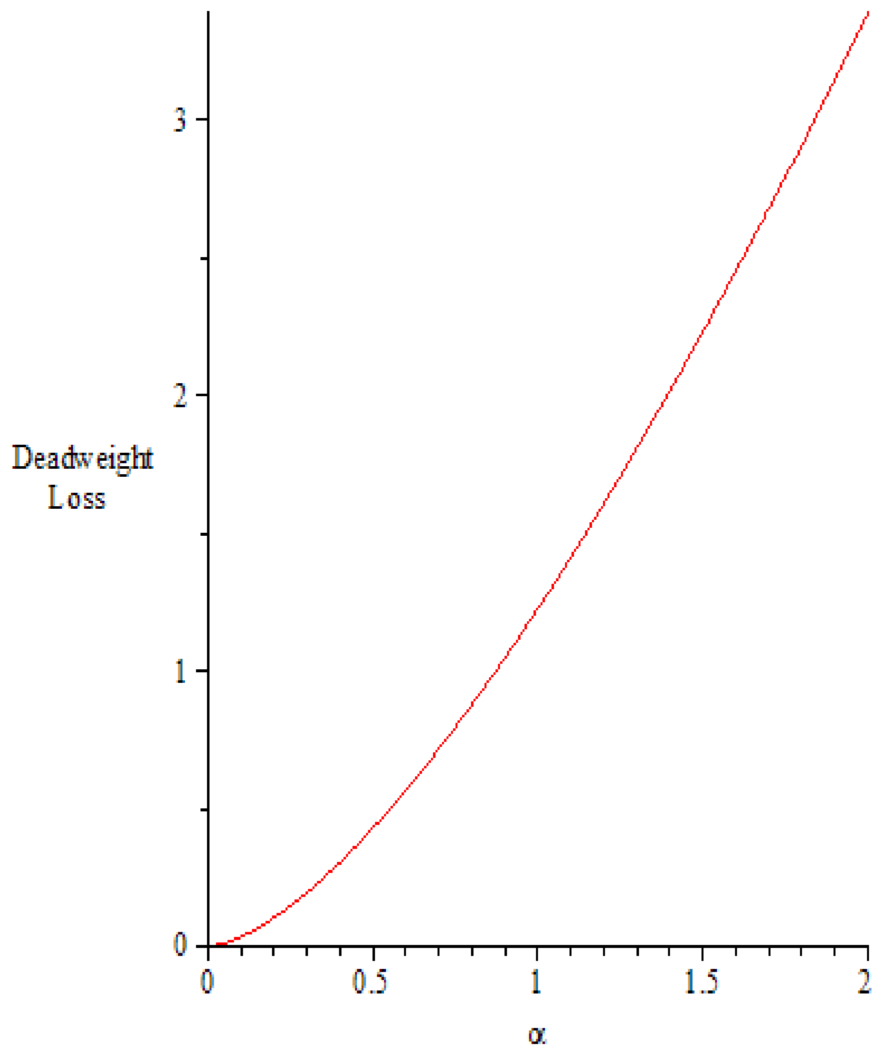
Appendix



Parameters: $y = 1$, $\alpha = 0.5$



Parameters: $\alpha = 0.5$, $\delta = 2$



Parameters: $y = 1$, $\delta = 2$

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