Municipal Land Use and the Financial Viability of Schools

Soji Adelaja
and
Melissa A. Gibson*
Land Policy Institute
305 Manly Miles Building
1405 South Harrison Road
East Lansing, MI 48823, USA.
Tel: 517-432-8800 X 102
Fax: 517-432-8769
e-mail: adelaja@msu.edu

Municipal Land Use and the Financial Viability of Schools

Abstract

Local schools are primarily funded through local property tax revenues, which are tied to property values and the distribution of value ranges within a community. Values, in turn, depend on the mix of lot sizes and building attributes (improvement characteristics). Since lot size restriction limit the size characteristics of homes (bedrooms, garages, building square footage, etc), it should constrain the number of school age kids emanating from a given homestead and that a school district services. Each home, depending on lot size, should exhibit differential impacts on school district revenues. Similarly, if lot size and the magnitude of other housing characteristics impact on the number of kids emanating from a home, then each home would generate differential costs on the school district as well.

This paper posits that an optimal lot size exists within a community that would maximize school district revenues, minimize school district costs or optimize the difference between both. A theoretical framework is developed to guide the specification of net revenue functions for school districts. By applying data from a school district in Michigan, net revenues are estimated as functions of lot size and other exogenous factors. The result suggests that net revenue is only feasibly optimal at lot sizes below approximately 0.18 acres. One implication is that school districts, which typically do not engage in local land use decision making, might consider the promotion of density and compact development which may be in their best interest.

Key words: Optimal lot size, zoning, school finances, district revenues and costs.

Municipal Land Use and the Financial Viability of Schools

Introduction:

Research is increasingly documenting the connections between land use decision making and the optimization of various societal goals. For example, Frumkin (2002) showed the relationship between land use patterns and community health, while Lopez et. al. (1988) estimated the impacts on agricultural performance and profitability. Other studies have shown the relationships between land use and loss of open space (Lopez et al., 1987; SEMCOG, 2003), environmental pollution and inner-city decay (Anderson, 2005; Anthony, 2004; and Austin, 2004), traffic/congestion (Ewing, 1997; Sarzynski et al., 2006, Wasserman, 2000), local food access, urban out-migration, social interactions (Leyden, 2003; Putnam, 1995; Schweitzer, 1999), resource allocation, rate of land consumption, property valuation, local infrastructure costs, land prices and fiscal health of communities (Burchell et al, 2002; Colton and Sheehan, 2001; Fischel, 1992; Foley, 2004; Gottlieb and Adelaja, 2004; Gottlieb and Adelaja, 2005; Jud, 1980; Mills, 1989; Najafi et al, 2006; Quigley and Rosenthall, 2005). Interest in the effects of land use on things that matter to people is expected to grow, as policy makers and their constituents seek to further understand the role of land use planning in shaping the future of communities.

Land use, itself, is driven by a broad set of factors, including existing road infrastructure, community appeal, quality of life, quality of schools and other drivers of demand for housing and business location in a given community (Carrison et al, 1956; Ebner, 1985; and Madden, 2003; Mundia and Ania, 2005). On the supply side, however, zoning is one of the few options that communities have to mitigate land use demand in order to achieve societal goals. The relationship between zoning, land use patterns and other issues people are concerned about have

been the subject of some studies. Adelaja, Rose-Tank and Derr (1986) for example, showed how zoning impacts on agricultural viability while (Foley, 2004) showed the impacts of zoning on land development.

A growing area of interest is the connection between land use and property tax revenues. In the United States, property taxes are the primary mechanism through which local communities and special taxing districts raise revenues to support the provision of services to their residents (Campbell, 1951). These taxes depend on real property values, and are therefore outcomes of growth patterns and the dynamics of real property formation. Because it affects the nature, volume and tax-rateability of future real property, zoning should ultimately affect future municipal revenues and therefore services (see Florestano, 1981). The link between zoning, land development by lot size, value distribution by land use class, and future tax revenues has been studied by Adelaja and Chaudhuri (2007). They concluded that for a given community, an optimal lot size exists that maximizes municipal revenues and argued that municipalities can be more optimal in managing their financial prospects through their zoning strategies.

The present paper extends the work of Adelaja and Chaudhuri (2007) to the area of school district revenues and costs. Local primary and secondary schools are funded via local taxes so that property values play a significant role in school district financing. In this study, we focus specifically on the relationships between zoning, land use, and school financial wellbeing. Of particular importance is the likelihood that land use choices, and therefore zoning, can impact school revenues and costs, through their impacts on development patterns. In Michigan, for example, school district buildings and renovations are funded through local millages. On the other hand, school operations are financed by the State School Aid Fund (funded from a portion of sales tax, income tax, use tax, real estate transfer tax and cigarette tax) which distributes funds

to schools based on the number of students in the school district (MSFA, 1994). Intermediate school districts are also funded through local tax millages. To the extent to which different lot sizes provide different valuation and taxes, which may or may not be proportionate to the number of school age kids they generate, the marginal movement to a larger lot size may yield differential impacts on cost and on revenues, implying that a range of optimal lot sizes exist that maximizes revenue, minimizes cost, and optimizes the difference. In other words, the distribution of housing types and values (by lot size) may affect net school tax revenues.

There are other reasons to believe that an optimal lot size may exist. Various property sizes vary in their propensity to generate school age children. It is expected that the number of school age children is related to housing characteristics and lot size, which are impacted by zoning. Certain lot sizes and their associated property attributes should be of greater demand than others due to consumer preferences, affordability, demographics, the needs of children and past land use regulations (Spangenberg and McCormick, 2002). Therefore, municipal revenues and costs are endogenous to land use patterns, and therefore zoning. The specific objective of this paper is to explain the relationship between zoning and school district revenues and costs by determining the housing lot sizes which optimizes school district revenues.

The balance of this paper is organized as follows. First, the basic fundamentals of the structures of revenue and cost for school districts are explained.[1] Secondly, a theoretical model is developed for evaluating optimal school tax revenues and costs, separately and together.[2] Third, a hedonic pricing framework is used to investigate the relationship between lot size and school net revenues, using Michigan as a national case study. An associated empirical hedonic

---

[1] Michigan's school funding formula is used as a framework. Such structures, though largely consistent across states, have unique variations from state to state. Our general framework could be modified easily to accommodate the specifics of any given state.

[2] The model explains the basic relationship between homestead value and lot size. This model can easily be adapted to the specifics of each state.

net revenue model is specified to include power terms on lot size so as to allow the estimation of an optimal lot size or multiple optima. Assessor data is combined with school district data on the number of children per home to conduct an empirical analysis for the City of Lansing, which is the capital of Michigan.

The results suggest that land use patterns affect school district operational funding directly through the number of students[3], as well as indirectly through property values which contribute to school capital funding.[4] The study further suggests that from a revenue and cost standpoint, choosing optimal land use regulation is a balancing act between school enrollment and the characteristics of real property. Schools therefore need to consider the complex implications of zoning if they seek to optimize their financing. Yet, in Michigan and other states, school districts are neither bound by local land use rules, nor do they seek to influence land use regulation.

The Nature and Structure of Local School Funding: A Conceptual Framework

Primary and secondary public education (K-12) are primarily considered to be a local public good in the United States. Therefore, a predominant mechanism that is being used to finance K-12 is local property taxes. In many states, local school districts can levy a millage on property values to generate revenues with which they operate or improve local schools. In many cases, such school districts are independent taxing districts, and are not always under the jurisdiction of municipalities (Wyckoff et al, 2008).

The independence of school districts from other municipal governments (local and county) often pits them against such municipalities. In some cases, school districts are not

---

[3] In Michigan, state funding for schools support school operations, and is distributed on the basis of school head count.

[4] In Michigan, local debt millages for schools basically support capital projects, including new construction, school improvements, and other capital needs.

subject to local land use regulations (Wyckoff et al, 2008), and municipal authorities have little ability to manage the taxes levied by school districts. School districts can organize their own campaigns for public referendum to initiate additional millage.[5] This independence might suggest that while municipalities and schools try to optimize their individual objective functions, opportunities are missed for joint utility maximization that might yield optimal community welfare.[6]

In the case of Michigan, as it is the case in many states, such as New Jersey, K-12 also receives revenue distributions from a central state budget (Arsen and Plank, 2003). This revenue source can only be applied to operating expenses, and is distributed on the basis of student population. Obviously, a school district would seek to maximize school enrollment as long as the marginal revenue exceeds the marginal cost, or seek to reduce the number of kids if marginal cost exceeds marginal revenue. The nature of revenue and cost function therefore determines net revenue optimality. The state's goal in distributing revenues this way is to maintain equity between wealthy and non-wealthy school districts since local tax based revenues for schools could be disproportionately low in poor school districts where property values are low.

As indicated above, to the extent to which zoning or other land use regulationsaffects lot size, it also impacts on the parameters that drive school district finance. For example, an area with high density residential zoning would probably feature smaller garages, smaller bedrooms, fewer bedrooms, lower housing square footage, and possibly fewer school age kids. As lot size increases, the number of school-age kids per home can be expected to increase monotonically, but up to a point where housing/improvement attributes maximize out and extra land no longer

---

[5] In the absence of influence on land use patterns, local school districts often resort to millages exclusively as the mode for changing their revenue profit.

[6] For example, if an optimal lot size exists that maximizes school net revenues, it might be in the school districts the best interest to join forces with local municipal officials that wish to adopt policies that promote compact development and density.

impact on the number of kids. Therefore, revenue source for the school district from a given home, which is related to the number of kids, will increase with lot size and may eventually flatten out. Similarly, school district costs are enrollment driven. As the number of kids increases, cost per home should increase. While economies of scale likely exist at the school district level, it is unclear how such economies manifest at the homestead level. With respect to lot size, larger lots might mean more school age children, if kids are directly related to housing attributes such as the number of bedrooms. Even then, the number of school age kids should also eventually flatten out as housing attributes max out in the attribute-lot size space.

To illustrate this point, we concentrate first on the revenue and cost generating capacity of a home. Let RT_j denote the total tax revenues generated by the jth home in a particular school district. Therefore, $RT_j = RS_j + RI_j + RD_j,$ where RS_j is revenue that accrues from the state's allocation of funds to the school district, RI_j is revenue attributable to millage collections for the intermediate school districts,[7] and RD_j is revenue from millages for capital expenditures of the school district (debt financing). RS_j attributable to a given home is a function of the number of kids (K_j). Hence,

$$RS_j = \sigma K_j \tag{1}$$

A school district's property tax-based revenues are based on the application of millage rates. That is,

$$RI_j = \tau_1 \gamma W_{H_j} \tag{2}$$

and,

$$RD_j = \tau_2 \gamma W_{H_j} \tag{3}$$

---

[7] The intermediate school district is a unique feature in some states. ISD revenues are used to fund regional district-wide activities such as special education, technical training, alternative education, bulk purchasing, etc.

where τ's are the millage (or tax) rates for the school district, γ is the proportion of assessed property value to the taxable value, and V_{H_j} is the assessed value of a homestead, which is assumed to be equal to the market value. The total revenue from a home is therefore

$$RT_j = RS_j + RI_j + RD_j = \sigma K_j + (\tau_1 + \tau_2)\gamma V_{H_j}. \tag{4}$$

In equation (4) RT_j is dependent on the property values of the home (V_{Hj}).

Now, let CT_j denote the total cost or expenditure of the school district on the jth home. This cost is a function of the average cost per kid in the school district (μ) and the number of kids in the jth home. That is,

$$CT_j = \mu K_j. \tag{5}$$

The net revenue from a home (RN_j) is,

$$RN_j = (\sigma - \mu)K_j + (\tau_1 + \tau_2)\gamma V_{H_j}, \tag{6}$$

and the total net revenue for all homes in a school district is

$$RN_T = \sum_{j=1}^{m} RN_j = \sum_{j}^{m} (\sigma - \mu)K_j + (\tau_1 + \tau_2)\gamma V_{H_j}, \tag{7}$$

where m denotes the number of homes in the school district. Note that $\sigma - \mu$ is the impact of the number of kids directly on net revenue, while $\tau_1 + \tau_2$ is the impact of property values. In the following section we further explain V_{H_j} and RJ_j in the context of lot size.

In equation (7), K_j is explicitly specified as exogenous. However, V_{H_j} is not purely exogenous, since it is determined by property attributes. Therefore, the determinants of V_{H_j} must be the exogenous variables in a model specified to estimate equation (7). V_{H_j} is inherently dependent on lot size and other property attributes.

To illustrate this point, consider the fact that homestead has two major attributes: (1) land, or L, (the size of which is measured by lot-size), and (2) improvements, or B, (typically measured in terms of attributes such as square footage, number of garages or bedrooms, number of stories, etc.). The value of land is directly related to lot size, although, the literature has shown that other features such as location, neighborhood characteristics and community social capital also impact property value. The value of improvements is directly related to the intensity of improvement attributes (Adelaja and Chaudhuri, 2007). Such attributes may include such things as the number of bedrooms, the number of full bathrooms, the number of half bathrooms, the square footage of the home, the square footage of the garage, the number of storey associated with the building, and other aspects of residential building and improvements on the land.

The value of the jth homestead (land and buildings) is:

$$V_{H_j} = V_{L_j} + V_{B_j} = P_{L_j} L_j + \sum_{i=1}^{n-1} P_{i_j} B_{i_j} \ . \tag{8}$$

In equation (8), the simplifying assumption is that pure land and land related improvements, such as landscaping and driveways, occur in fixed proportions with lot size, while all other improvements are associated with the building. Hence, V_{H_j} is the value of the entire homestead. V_{B_j} is the value of building related improvements. V_{L_j} is the value of the land. P_{L_j} is the per acre value of land (or price). The P_{i_j} vector is a vector of per unit prices or values of the ith element of building-related improvements, while B_{i_j} is the degree of magnitude or scope of the ith improvement type on the jth property. In equation (8), n is the number of attributes associated with a homestead, n-1 of which are non lot size related.[8] Net revenue of a school district from a

---

[8] Other homestead attributes not tied to the improvements or land includes density of the area and school quality in the area.

piece of residential property is therefore the product of the appropriate tax rates and V_{H_j}. So,

$$RN_j = (\sigma - \mu)K_j + (\tau_1 + \tau_2)\gamma V_{H_j} = (\sigma - \mu)K_j + (\tau_1 - \tau_2)\gamma(P_{L_j}L_j + \sum_{i=1}^{n-1} P_{i_j}B_{i_j}). \qquad (9)$$

In equation (9), $\tau_1 - \tau_2$ is the effective tax rate, and γ is the proportion of property value that is taxable. Note that many communities set taxable values below the assessed value ($\gamma < 1$).

Equation (9) includes prices and quantities of land and improvement attributes. Obviously, since families are expected to chose homes that maximize their utility, household demand for attributes will depend on the number of school age children (for example, the larger the number of children, the greater the demand for bedrooms, garages, and even land for household recreation, subject to the family's income constraint). Alternatively said, the number of kids is limited somewhat by household characteristics. The estimation of equation (9) would yield marginal impact of kids, lot size, and other building attributes on net revenue. The parameter estimates will reflect the τ's, γ, and the P_i's. However, the attributes of a homestead (L_j and B_{i_j}) may be seen as not truly exogenous, as families can be assumed to chose these attributes based on their expectations about K_j.

To gain some insight on how V_H varies with lot size, we derive the following equations. Differentiating each side of equation (9) with respect to L, one obtains:

$$\frac{\partial V_H}{\partial L} = \frac{P_L \partial L}{\partial L} + \frac{L \partial P_L}{\partial L} + \sum_{i=1}^{n-1}\left(\frac{P_i \partial B_i}{\partial L} + \frac{B_i \partial P_i}{\partial L}\right). \qquad (10)$$

Note that in (10), the jth subscript is suppressed for ease of comprehension. Equation (10) can further be expressed as follows:

$$\left(\frac{V_H}{L}\right)*\left(\frac{\partial V_H}{\partial L}*\frac{L}{V_H}\right)=\left(\frac{P_L * L}{L}\right)\left(\frac{\partial L}{\partial L}*\frac{L}{L}\right)+\left(\frac{L * P_L}{L}\right)\left(\frac{\partial P_L}{\partial L}*\frac{L}{P_L}\right)+$$

$$\sum_{i=1}^{n-1}\left(\frac{P_i * B_i}{L}\left(\frac{\partial I_i}{\partial L}*\frac{L}{B_i}\right)+\frac{P_i * B_i}{L}*\left(\frac{\partial P_i}{\partial L}*\frac{L}{P_i}\right)\right). \tag{11}$$

Since $V_L = P_L L$, $V_B = \sum_{i=1}^{n-1} P_i B_i$, $S_L = \dfrac{V_L}{V_H}$ = the share of property value attributable to land or the

lot, and $S_i = \dfrac{V_i}{V_H} = \dfrac{P_i B_i}{V_H}$ = the share of property value attributable to each property improvement

or building attribute, the following can be derived from equation (11)

$$\xi_{V_H,L} = S_L + \left[S_L * \xi_{P_L,L}\right] + \left[\sum_{i=1}^{n-1}\left(S_i * \xi_{Bi_iL} + S_i * \xi_{P_i,L}\right)\right] \tag{12}$$

where

$$\xi_{V_H,L} = \left(\frac{\partial V_H}{\partial L}*\frac{L}{V_H}\right), \tag{13}$$

$$\xi_{P_L,L} = \left(\frac{\partial P_L}{\partial L}*\frac{L}{P_L}\right), \tag{14}$$

$$\xi_{B_i,L} = \left(\frac{\partial B_i}{\partial L}*\frac{L}{B_i}\right), \tag{15}$$

and

$$\xi_{P_i,L} = \left(\frac{\partial P_i}{\partial L}*\frac{L}{P_i}\right). \tag{16}$$

The elasticity of homestead value with respect to lot size is

$$\xi_{V_H,L} = \left[S_L\left(1 - \xi_{P_L,L}\right)\right] + \left[\sum_{i=1}^{n-1}\left(S_i\left(\xi_{Bi_iL} + \xi_{P_i,L}\right)\right)\right], \tag{17}$$

suggesting that the marginal effect of increased lost size on property value, and therefore school

tax revenue, depends on the relative shares of land and improvements (S_L and S_i), the elasticity

of land price with respect to lot size ($\xi_{P_L,L}$), the elasticities of demand for various improvements with respect to lot size ($\xi_{B_i,L}$), and the elasticities of the prices of improvements with respect to lot size ($\xi_{P_i,L}$).[9]

$\xi_{P_L,L}$ is expected to be negative because as lot size increases, the per unit cost of land should decline (Tabuchi, 1996). Adelaja and Chaudhuri (2007) attribute this largely to economies of scale in infrastructure and land construction. On the other hand, the value of improvements (homestead less the lot) should be directly related to lot size, at least over a range of lot sizes. Therefore, $\xi_{B_i,L}$ should be positive as increased lost size should result in greater demand for building attributes. Finally, $\xi_{P_i,L}$ should be negative as the per unit cost of various improvements should decrease due to greater economies of scale. Therefore, depending on lot size range, as lot size increases, the change in property value could be positive or negative.

Empirical Model Specification

The goal of this study is to estimate a net revenue function for a selected school district, in order to determine whether or not an optimal range of lot size exists where school district revenue would be maximized. The existence of such optimal lot size would suggest that school are better off promoting a certain range of housing density in order to maximize their financial prospects. The conceptual model above is helpful in identifying the types of variables that should be included in a regression model of net revenue for a school district. The idea is to utilize data from different homes in the estimation of a net revenue function.

---

[9] The focus on lot size in equation (17) is to allow the isolation of cost-size effects. Note that equivalents of equation (17) exists for each of the B_i's. From (17), it is easily seen that :

$$\xi_{V_H,B_I} = \left[S_I \left(1 - \xi_{P_I,B_I} \right) \right] + \left[S_I \left(\xi_{L,B_i} + \xi_{P_L,B_I} \right) \right] + \left[\sum_{i=1}^{n-2} \left(S_i \left(\xi_{B_iB_I} + \xi_{P_L,B_I} \right) \right) \right].$$

To operationalize the conceptual model above, we propose to regress school net revenue against its determinants, with a special focus on lot size. Since the property tax-based elements of school revenues depend on property values, which can be explianed using equation (17), an augmented hedonic pricing model is used as the basic empirical framework (see Griliches, 1971). Hedonic pricing models have been used to value location, structural and environmental amenities associated with residential property (Goodman and Thibodeau, 1995; Quigley and Rosenthal, 2005; Rosen, 1974).

Following Goodman and Thibodeau (1995), and based on equation (17), the specific attributes included in our empirical model are: the square footage of the home above ground (B_1), the number of bedrooms (B_2), the number of full bathrooms (B_3), the number of half-bathrooms (B_4), the square footage of garages (B_5), the square footage of the basement (B_6), lot size (L), the number of kids per home (K), and a dummy variable for homestead exemption (D). In one specification (Model 1) up to the third order of power for L is included, based on the idea that the net revenue function may have more than one optima. Model 2 is then specified based on the assumption of one maxima. Hence, the general specification for the hedonic net revenue function is:

$$RN = f\left(\beta_1, \beta_2, \beta_3, \dots \beta_m, K, D, L, L^2, L^3\right), \tag{18}$$

With the coefficient of L^3 constrained to zero in Model 2. The estimated coefficients are marginal willingness to pay for the ith attribute of the the jth household. Equation (18) is estimated assuming a basic linear functional relationship.[10] The simplifying assumption is make in equation (18) that housing attributes are truly exogenous. To relax this assumption, additional

---

[10] D is added to the regression as a dummy variable because in Michigan, owners of non of non-primary homes are required to pay a homestead premium. The dummy variable takes on a value of 1 for homes with no homestead tax exemption.

equations to explain each building attribute in equation (18) would need to be estimated. The specification of such equations will take the form

$$B_i = f(K), \text{ (for all } i), \tag{19}$$

and

$$L = f(K). \tag{20}$$

Equation (18) through (20) would have to be estimated as a system.

Data

The Lansing School District in Mid-Michigan is utilized as a case for the model estimation. The Lansing School District is a large, urban district, composed primarily of the City of Lansing, with over 33 schools and 16,007 students in K-12 (Lansing School District, 2006). Both property assessment data and student location information was collected so that public school kids could be matched with the characteristics of their housing. Specific student address information was obtained for all Lansing School District students for the school year 2005-2006, to be able to allocate the appropriate number of students to the correct property, and hence property characteristics. Property assessment information was collected for the City of Lansing, as well as the portion of Clinton County falling within the Lansing School District for 2007. While other communities have property which is included in the Lansing School District, the low number of properties and students that would be gained from additional data collection would not justify the additional work necessary to accomplish this. Student address information was available for 14,964 of the Lansing School Districts students. Based on the limits of the City of Lansing and Clinton County within the Lansing School District, we were able to match 13,266 students to property information.

Only parcels identified as being real residential property (class 401) were utilized in this analysis. Apartment and duplex communities and mobile home complexes, which are largely classified as commercial (201) are excluded from the analysis primarily due to the fact that acreage information and apartment/housing characteristics are largely lacking. Only properties with identified taxable value and acreage (lot size) are included, resulting in 10,881 students and 36,206 properties possible for estimation. This equates to roughly 67.98% of the total Lansing School District student population, according to their reported number of students for the 2005-2006 school year (LSD, 2006), or approximately 72.71% of the students with available address information.[11] Given the nature of the data, there was no reason to believe that our data was not representative of the school district.

School capital revenues are based on taxes of all properties at a rate of 2.4719 mills for the year 2005, which is applicable to the 2005-2006 school year (ICAR, 2005). Operational millage of 17.9262 applies to non-homestead properties, and contributes to the state school aid fund which is distributed to all school districts on a per-pupil bases (ICAR, 2005). Since the taxable value of the property is in terms of 2007 value, while the student address data and millage information is based on the 2005 year, estimated costs and revenues could be slightly higher than they actually were in 2005. However, due to a downward correction in property values across the region after 2005, property values in 2007 may be closer to their levels in 2005.

Table (1) provides a detailed discussion of the nature of the variables in the estimated model. The dependent variable for the net revenue function, (*RN*), is the difference between the total revenue per home and total cost per home for the school district. Total revenue per home is the sum of debt tax revenue (debt millage rate times the taxable value of a property) plus the per

---

[11] The elimination of apartment and duplex complexes is not seen as posing a serious problem. Our regression estimates could be interpreted as depicting optimal single family home density.

kid state revenues generated ($7,280 per student times the number of student in a home). Taxable value was used in estimating revenues. Since the passing of Proposal A into Michigan law in 1994 provides a cap on property tax increases as long as property ownership remains the same, the assessed value may be different than the taxable value. This places a constraint on a school district with revenues not increasing as fast as property values. The independent variable of particular interest is lot size in acres (L), as well as L^2 and L^3.

Total cost per home was calculated as the projected total expenditures (total revenues received from homes and the state) divided by the number of kids in the analysis, for a per kid cost of $7585.24. This was allocated to homes base on the number of children present. The error term associated with equations (18) through (19) are assumed to be normally distributed, with means of zero and constant variances. For the purpose of this paper, equations (19) and (20) are dropped because the focus is on lot size impact. The ordinary least squares (OLS) regression technique was used in estimating the model in equation (18).

Empirical Results

Table 2 summarizes the regression results for the two versions of equation (18) and specifies the level of significance for each of the independent variables. The estimated R^2, were, respectively, 0.768 for Model 1 and 0.765 for Model 2. For cross sectional data, this is remarkably high. Durbin-Watson statistics suggest the absence of heterosckedasticity. All parameter estimates were significant at the 1% level in both models. The signs and magnitudes of the estimated coefficients were consistent with expectations. Across both models, the magnitudes were very close, except for the coefficients related to lot size. Recall that in Model 1, a cubic function was specified with respect to lot size, while in Model 2, a squared function was specified.

Across both models, the marginal impacts of additional housing square footage were positive (B_1 is $0.035 and $0.034 respectively). This suggests a 3.5 cent increase in net school tax revenue for every additional square foot of housing space. Homestead square footage is obviously a profit center for schools, due to its greater positive impact on revenues than costs. This is consistent with previous hedonic studies on property values (Rosen, 1974; Li and Brown, 1980).

However, across both models, the marginal impact of an extra bedroom on net school tax revenue is negative (B_2 is -$2.260 and -$2.759 respectively). This suggests that as the number of bedrooms increases, revenues increase less than cost, resulting in a net school tax revenue decline. This makes intuitive sense, considering that bedrooms tend to be correlated with family size. Bedrooms are obviously not a profit center for schools.

The marginal impact of an extra full bathroom on net school tax revenue is positive (B_3 is $5.624 and $6.200 respectively). This suggests that full bathrooms are profit centers, as they increase revenues more than costs, resulting in an increase in net school tax revenue. It appears that parents trade off bedrooms for bathrooms in accommodating more children. Similarly, the estimated coefficients for half bathrooms (B_4) were $12.28 and $11.78, for Models 1 and 2, respectively. The fact that half baths are better net tax rateables than full baths seems intriguing, but it appears that the property valuation prosses is more generous in valuing half bathrooms.

Garages seem to add very little net revenue, probably because the impact on tax revenue is about the same as the impact on school costs. The estimated coefficients of B_5 were, respectively, $0.03 and $0.02. The same applies to basement square footage ($B6$), where the coefficients were $0.02 for both models.

The dummy variable (*D*) included for homestead tax exemption yielded parameter estimates with an intriguing sign. The average home with no full homestead tax exemption, paid $12.34 less in net tax revenues, according to Model 1, and $11.24 less, according to Model 2. Properties will less than full homestead tax exemptions tend to be rental properties. The results therefore suggest that rental properties tend to generate more costs on the school system than they bring in, in revenues. It appears that renters, tend to live in lower value homes, and perhaps generate kids who add more to school district costs than revenues generated from property taxes.

The estimated coefficients for *K*, our last non lot-size related variable, are -$32.5859 and -$32.484 respectively. It appears that despite the kids-based revenue allocation formula by the state, homes with more kids raise school district costs more than they increase tax revenue. Recall that kids enter the equation in two ways. On one-hand, schools are rewarded by the state on the basis of the number of kids they have. However, kids also must be serviced by the school district. It appears that, on average, an increase in the number of kids in a school district results in less financial viability.

Finally, examine the coefficients associated with lot size. For Model 1, *L*'s estimated coefficient is -$216.34. L^2's estimated coefficient is $94.568, and L^3's coefficient is -$8.401. This cubic specification suggests the existence of two optima 1.41 acres for lot size (minimum) and 6.1 acres (maximum). The lot size range at which the net revenue function falls below zero is from .17 acres to 2.93 acres. It is doubtful that any school would want to operate within that range. The ranges at which the net revenue function lies above zero are between 0 acres and 0.16 acres, and 2.94 acres and above. An examination of the lot sizes in the City of Lansing suggests very few homes in the 2.94 and above lot size range. It therefore appears that there is a very tight range (0 to 0.16) within which schools can effectively maximize their net revenues.

This suggests that a very low lot size is the most desirable and feasible lot size for revenue optimization. This is an important finding in the sense that is suggests that high density is more profitable for the Lansing School district. This is illustrated in Figures 3 and 4.

For Model 2, L's estimated coefficient is -$116.405 and L^2's estimated coefficient is $14.261. The squared specification therefore suggests two ranges of lot size. In the first range, 0 to 0.18, net revenue is above zero. In the second range (0.19 to 7.97) net revenue is below zero and only becomes greater than zero again at 7.98 acres. This further buttresses the notion that very low lot sizes are more desirable than larger lot sizes. Figure 3 plots out the net revenue curves for Model 1 and 2, while figure 4 magnifies these curves for the 0 to 1.5 acre range.

Conclusions

There has been significant debate about whether or not density is good for communities. Adelaja and Chaudhuri (2007) demonstrated, in the cases of Meridian Township, Michigan and Hillsdale County, Michigan, that density is indeed preferable, from the standpoint of municipal revenues. In this paper, we re-examine the issue of density, but this time with a focus on the revenues and costs associated with the education of kids within an urban school district. The results buttress the notion that density is good.

Highly compact homes, on very small lots, are found to yield the most positive feasible set of net revenues per house. While the results indicate that net revenues could actually be better at very large lot sizes, such optima are not feasible in the cases of cities for two reasons: 1) few cities have large lots still available for single family homes; and 2) even if they did, there are only a few of them. Our study suggests that school districts should at least be interested in the process of planning and zoning in their communities. In many places this is not the case, and

school officials see density as something that is exogenous to their wellbeing or completely out of their control.

In another study by the authors (see Wyckoff et al, 2008), it was found that Michigan has experienced drastic losses in population and public school enrollment in urban areas, while non-urban areas have gained population and kids in recent decades. This has led to massive school closure in cities and the development of new schools in non-urban areas. The study also found, however, that the current recession in the state and the acute recession in some parts of the state has created a situation where newer non-urban schools are increasingly facing financial challenges and experiencing the incidence of closure. Many of these "Taj Mahal" schools were build away from population concentration areas, where housing density is typically low. Such schools are typically blamed for adding to the sprawl problem. To the extent to which the findings of this study are applicable to other communities outside Lansing, perhaps density is also good in non-urban communities. In other words, if net revenue performance is better at high density, it does not serve schools well to build at low density. Given the revenue function estimates from this study, it appears that the prospects of suburban schools would be better if they built schools closer to urban concentration areas and not contribute to the sprawl that has characterized suburban and rural school districts. To the extent to which schools can re-build old schools, or build new schools in the center of town, they can probably contribute to their own financial performance by not fostering the kinds of low density development they have fueled in the past.

On a final note, this paper presents estimates that shed better light on the impact of building improvement attributes by showing which features of housing are better net school revenue generators than others. The study provides some guidance as to how non-lot size related

factors contribute to school financial viability. In other words, larger home square footage is good, and so are the number of full and half bathrooms. They simply add value to property and therefore enhance property values without causing costs proportionally. Garage and basement square footage are also good for schools. Bedrooms appear not to be good for schools. This is consistent with the findings for the direct effect of school children. It appears, therefore, that while large homes generate more kids and the schools are rewarded by the state for this, they also increase school costs more than they bring in revenues to the school. Rental properties are good rateables, vis-à-vis single family home. However, more students per acre contribute to less viability.

Table 1: Variables Used in the Hedonic Pricing Modeling of Net School Revenue in the Lansing School District, Michigan. *

| Variables	Variable Symbol	Description and Measurement	Nature of Variable
Dependent Variable			
Net School Revenue	RN	School district revenue per household minus school district cost per household.	Continuous.
Independent Variables			
Square footage above	B_1	Total square footage of the house above the ground.	Continuous.
Bedrooms	B_2	Total number of bedrooms.	Discrete, 1 or 2 or 3 etc.
Full bath	B_3	Number of full bath.	Discrete, 1 or 2 or 3 etc.
Half bath	B_4	Number of half bath.	Discrete, 1 or 2 or 3 etc.
Square footage of garages	B_5	Total square footage of garage.	Continuous
Square footage of a basement	B_6	Total square footage of basement.	Continuous.
Total lot size	L	Total lot size of the house, in acres.	Continuous.
Homestead status, dummy	D	Dummy = 0 if 100% homestead, 1 otherwise.	Discrete, 1 or 0.
Public school kids per acre	K	Number of students per acre.	Continuous

* The data came from property assessment information from the City of Lansing and the Lansing School District portion of Clinton County, Michigan.

Table 2: Estimated Effects of Parcel Attributes on School District Revenue in Lansing, Michigan.

Variable Name	Parameters Estimates	
	Model I	Model II
Constant	32.401 *	20.946*
B_1 (ABOVE SQFT)	0.035*	0.034*
B_2 (BDRMS #)	-2.260 *	-2.759*
B_3 (FULLBATH #)	5.624*	6.200*
B_4 (HALFBATH #)	12.278*	11.781*
B_5 (GARSQFT)	0.030*	0.023*
B_6 (BSMTSQFT)	0.022*	0.022*
L (LOTSIZE)	-216.338 *	-116.405*
L_2 (LOTSIZE^2)	94.568*	14.261*
L_3 (LOTSIZE^3)	-8.401*	
D (DHMSTD)	-12.345*	-11.243*
K (STUDENT/ACRE)	-32.5859*	-32.484*
R-square	0.768	0.765
* represents significance at the 1% level.		

**Figure 1: Conceptualized Effect of Lot Size on Student Enrollment and School Revenue and Cost: Typical Home.**
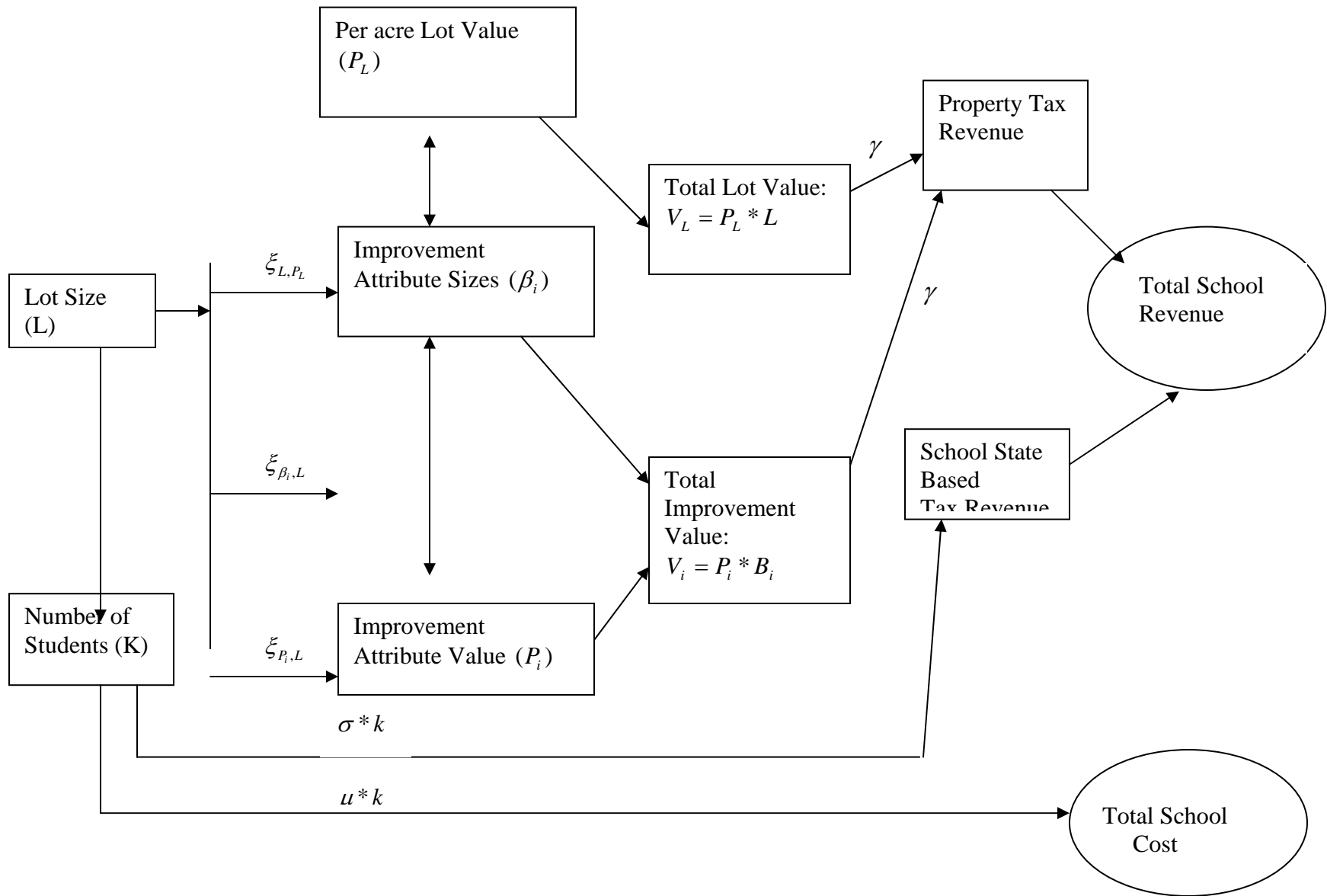
**Figure 2: Lansing School District, Michigan: Aggregate Student Location by Address.***
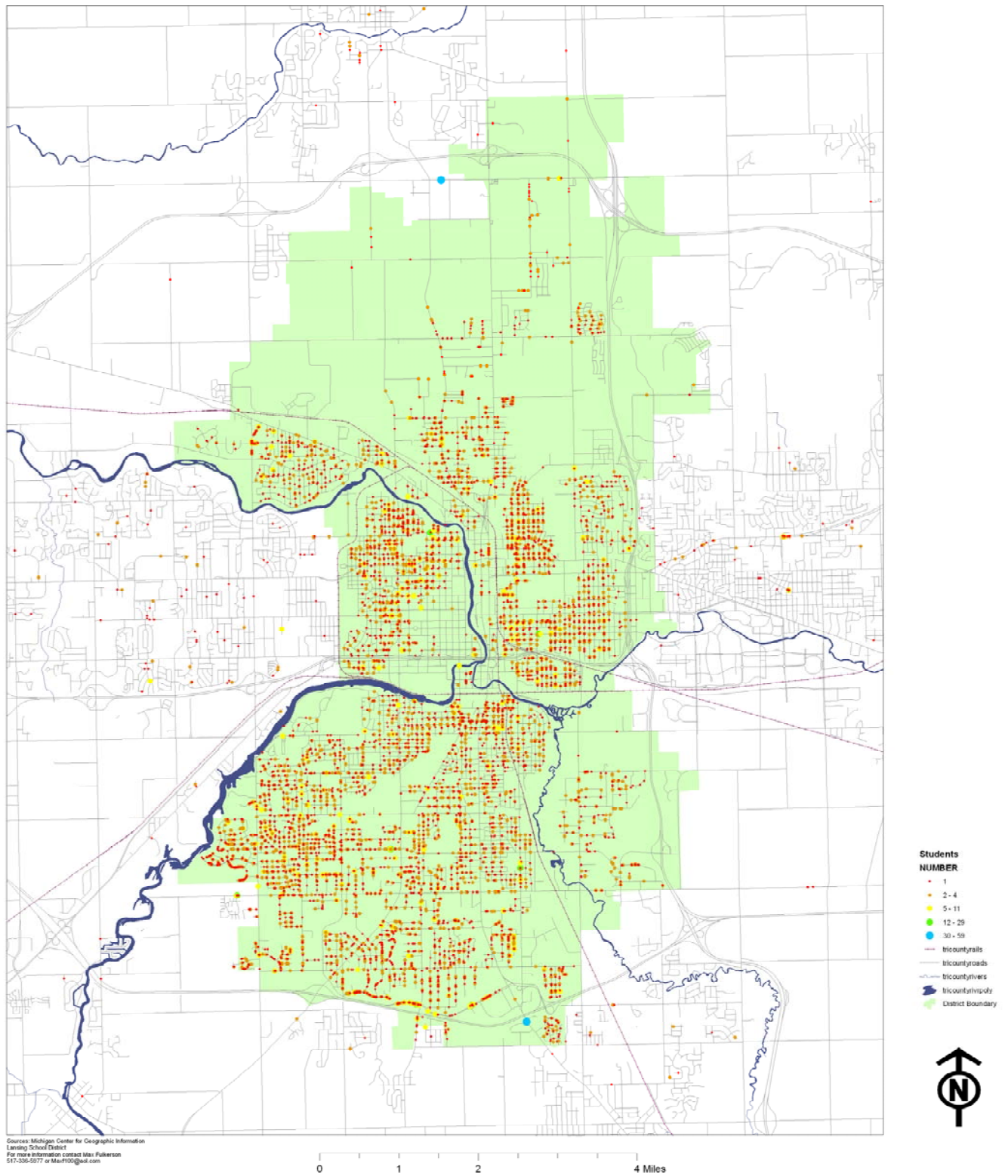
*Note, students residing in apartment/mobile home or duplex communities are included in the aggregate number, hence, the occurrence of large numbers of students at one address.

Figure 3: Projected Net Revenue Functions by Lot Size in Lansing, Michigan: 0 to 8 acres.
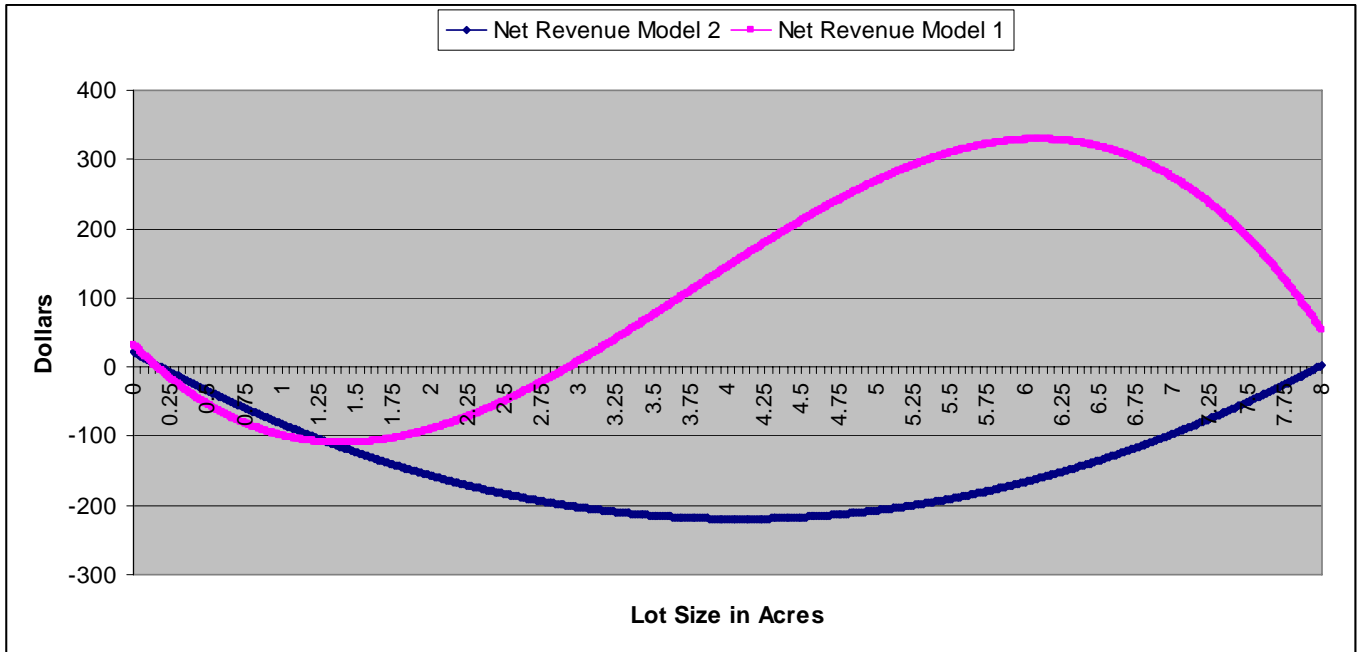
Figure 4: Projected Net Revenue Functions by Lot Size in Lansing, Michigan: 0 to 1.5 acres.
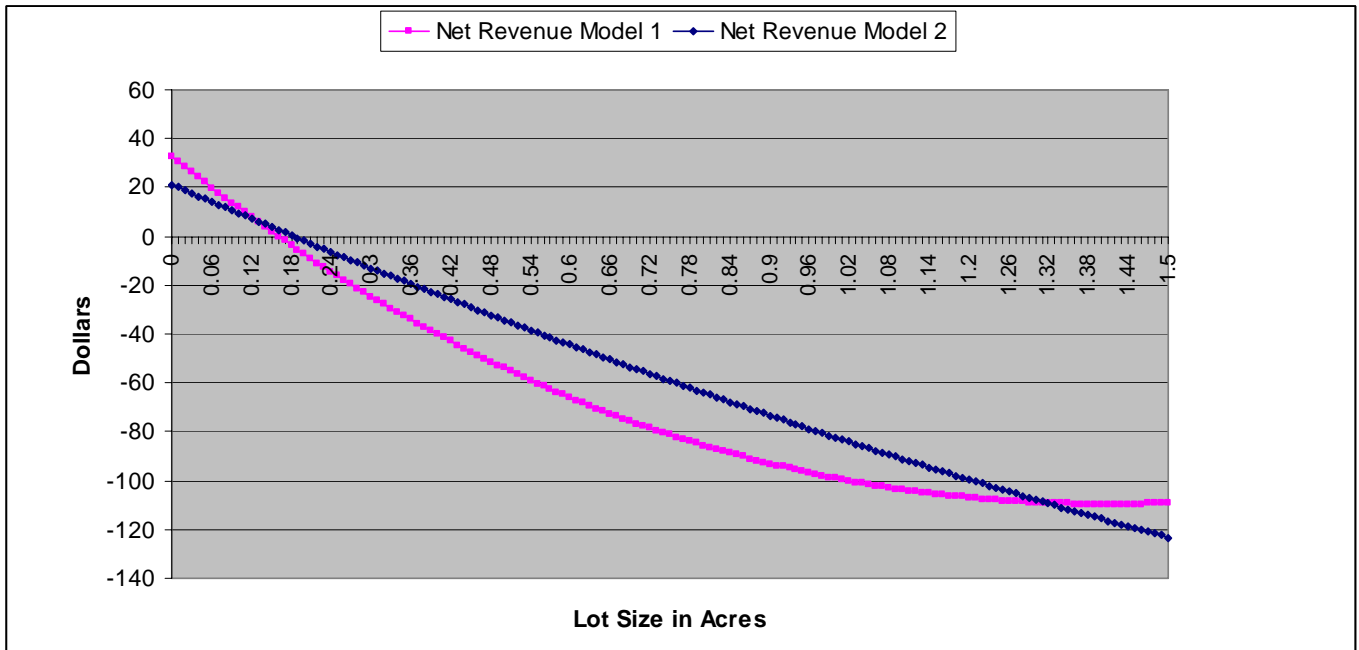
References

Adelaja, A. and M. Chaudhuri, "Optimal Density for Municipal Revenues." *Land Policy Institute Working Paper* 2007-15: Land Policy Institute, Michigan State University, East Lansing, MI. 2007.

Adelaja, A., Derr, D., and Rose-Tank, K., "Economic and Equity Implications of Land-Use Zoning in Suburban Agriculture." *Journal of Agricultural Ethics,* 2, (1989) pp. 97-122.

Adelaja, Adesoji O., and Paul D. Gottlieb, "The Political Economy of Downzoning." Selected Paper prepared for presentation at *The American Agricultural Economics Association Annual Meeting*, Denver, Colorado, August 1-4, 2004.

American Farmland Trust, "Cost of Community Service Studies." *Farmland Information Center Fact Sheet*, (2004).

Anderson, B. "Choices in Zoning: The High Cost of Density," White Paper, Michigan Township Association, 2005.

Anthony, J. "Do State Growth Management Regulations Reduce Sprawl?" *Urban Affairs Review*, 39 No. 3, (2004), pp. 376-397.

Austin, M.E. "Resident Perspectives of the Open Space Conservation Subdivision in Hamburg Township, Michigan,: Landscape and Urban Planning, 69:2-3, (2004) pp. 245-253..

Arsen, D. and D. Plank, "Michigan School Finance under Proposal A: State Control, Local Consequensces." The Education Policy Center at Michigan State University, East Lansing. (2003).

Burchell, R.W., G. Lowensein, W.R. Dolphin, C.C. Galley, A. Downs, S. Seskin, K.G. Still and T. Morre, "Costs of Sprawl –2000." TCRP Report 74, Transportation Research Board, (2002).

Campbell, Colin D., "Are Property Tax Rates Increasing?" *The Journal of Political Economy*, Vol. 59, No. 5. (Oct., 1951), pp. 434-442.

Colton, Roger D. and Michael Sheehan, "Inclusionary Zoning for Belmont: The Public Need and the Private Exaction." April. url: http://www.fsconline.com/work/he/belmont-nexux-study.pdf. (2001).

Ewing, R. "Is Los Angeles Style Sprawl Desirable?" *Journal of American Planning Association*, 63, (1997), pp. 107-126.

Fischel, William A., "Property Taxation and the Tiebout Model: Evidence for the Benefit View from Zoning and Voting." *Journal of Economic Literature*, Vol. 30, No. 1, (Mar. 1992), pp. 171-177.

Florestano, Patricia S., "Revenue-Raising Limitations on Local Government: A Focus on Alternative Responses." *Public Administration Review*, Vol. 41, Special Issue: The Impact of Resource Scarcity on Urban Public Finance. (Jan., 1981), pp. 122-131.

Foley, Brian P., "The Effects of Residential Minimum Lot Size Zoning on Land Development: The Case of Oakland, Michigan." *Unpublished M.S. Thesis*, Department of Agricultural Economics, Michigan State University, (2004).

Frumkin, H., "Urban Sprawl and Public Health." *Public Health Reports* Vol. 117, (2002).

Goodman, Allen C. and Thomas Thibodeau, "Age-Related Heteroskedasticity in Hedonic House Price Equations." *Journal of Housing Research*, Vol. 6, Issue 1, (1995).

Gottlieb, Paul D. and Adesoji O. Adelaja, "Down-Zoning and Its Impact on Property Value." Under review by *The American Journal of Agricultural Economics* and resubmitted on April 24, 2008.

Griliches, Z., "Price Indexes and Quality Change." Harvard University Press, Mass, (1971).

Ingham County Apportionment Report (ICAR). "Statements Showing Taxable Valuations and Mills Apportioned by the Board of Commissioners for the Year 2005." Ingham County Equalization.

Jud, G. Donald, "The Effects of Zoning on Single-Family Residential Property Values: Charlotte, North Carolina." *Land Economics*, Vol. 56, No. 2, (May 1980).

Lansing School District, Report on Financial Statements, (June 2006).

Leyden, D.M., "Social Capital and the built Environment: The Importance of Walkable Neighborhoods." *American Journal of Public Health*, 93, (2003), pp. 1546-1551.

Li, Mingche M., and H. James Brown, "Micro-Neighborhood Externalities and Hedonic Housing Prices." *Land Economics*, Vol. 56, No. 2 (May, 1980), pp. 125-141.

Lopez, R. A., A.O. Adelaja, and M.S. Andrews, "The Impact of Suburbanization on Agricultural Production Choices." American Journal of Agricultural Economics, 69(5), (1987).

Mills, David E., "Is Zoning a Negative-Sum Game?" *Land Economics*, Vol. 65, No. 1. (Feb., 1989), pp. 1-12.

Najafi, M., R. Mohamed, A. Tayebi, A.O. Adelaja, M. Lake, P. Gottlieb, et al. "The Fiscal Impacts of Alternative Single Family Housing Densities: Infrastructure Costs." The Land Policy Institute, Michigan State University, East Lansing, MI. 2006.

Putnam, R.D., "Bowling Alone: America's Declining Social Capita.," *Journal of Democracy*, 6, (1995), pp. 570-587.

Quigley, John M. and Larry A. Rosenthal, "The Effects of Land Use Regulation on the Price of Housing:What Do We Know? What Can We Learn?" *A Journal of Policy Development and Research*, Vol. 8, No. 1, (2005),

Rosen, Sherwin, "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." *Journal of Political Economy*, Volume (Year): 82 (1974), Issue (Month): 1 (Jan.-Feb.), Pages: 34-55.

Sarzynski, A., H. Wolman, G. Galster, and R. Hanson, "Testing the Conventional Wisdom about land Use and Traffic Congestion: The More We Sprawl, the Less We Move?" *Urban Studies*, 43(3), (2006).

Schweitzer, J., J.W. Kim, and J. Mackin, "The Impact of the Build Environment on Crime and Fear of Crime in Urban Neighborhoods." *Journal of Urban Technology*, 6(3), (1999), pp. 10-16.

SEMCOG, "Land Use Change in Southeast Michigan: Causes and Consequences." Detroit: Southeast Michigan Council of Governments, (2003).

Spangenberg, John and Michael McCormick, "Housing in the Community: Choice, Availability and Affordability." 2002. url:http://warealtor.com/government/qol/policies/qolhousinggoals.pdf.

Tabuchi, Takatoshi, "Quantity Premia in Real Property Markets." *Land Economics*, Vol 72, No. 2. (May, 1996), pp. 206-217.

Wasserman, M., "Confronting Urban Sprawl." *Regional Review of the Federal Reserve Bank of Boston*, (2000), pp. 9-16.

Wyckoff, M., S. Adelaja, Y.H. Hailu and M. A. Gibson, "The Implications of School Location Change for Healthy Communities in a Slow Growth State: A Case Study of Michigan." Critical Issues Symposium on School Siting and Healthy Communities, Florida State University. (April, 2008).