

## Financing transportation with land value taxes

### Effects on development intensity

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**Abstract:** A significant portion of local transportation funding comes from the property tax. The tax is conventionally assessed on both land and buildings, but transportation increases only the value of the land. A more direct and efficient way to fund transportation projects is to tax land at a higher rate than buildings. The lower tax on buildings would allow owners to retain more of the profits of their investment in construction, and would be expected to lead to higher development intensity. A partial equilibrium simulation is created for Minneapolis, Richfield and Bloomington, Minnesota to determine the intensity effects of various levels of split-rate property taxes for both residential and nonresidential development. The results indicate that split-rate taxes would lead to higher densities for both types of development in all three cities.

**Keywords:** Value capture; Property tax; Split-rate land tax; Development intensity; Density; Minnesota

### 1 Introduction

The accessibility of a property has a substantial value that is capitalized in the price of the land. Conventional property taxes capture this value to some extent, but also depend on the nature of the structures on the property, which do not derive value from transportation access. Funding transportation with a split-rate property tax, in which land is taxed at a higher rate than buildings, is a more direct way to capture the related value while also improving the incentive structure for developers. A parcel of land has a value based on surrounding improvements the community has made, and an increase in the tax on land allows the community to keep a greater portion of the value generated by public projects. Buildings have value based on the effort and expense the owners have incurred to construct them, and a corresponding decrease in the tax on improvements allows property owners to keep more of the value they have created for themselves.

The component of conventional property tax that reflects building value creates a disincentive for owners to improve their properties and results in less construction than would likely occur in an untaxed market. In contrast, the portion of the property tax that falls on land has no effect on land supply. Reducing the tax on buildings thus improves economic

efficiency, while raising the tax on land to maintain revenue neutrality does not cause a corresponding efficiency loss (Cohen and Coughlin 2005). An increase in the levy on land also gives landowners an incentive to develop their properties for a higher economic purpose; in theory, this discourages the speculative holding of vacant parcels, as the higher tax rate causes owners either to develop or to sell to someone who will. A corresponding decrease in the levy on buildings enables property owners to commit more funds toward development without having to account for as great a rise in property tax. Future urban development is then expected to follow a more centralized, compact pattern (Batt 2003). This increased density, in turn, makes the provision of public transit service more feasible (Parsons Brinckerhoff 1996; Pushkarev and Zupan 1977).

Because the property tax is only partially based on land value, owners can profit at the expense of others when the value of their land increases because of improvements to infrastructure or to nearby properties. Transportation projects can generate land value increases well in excess of their costs, and to capture a portion of this gain would be sufficient to fund some projects without additional public expenditure (Batt 2001; Benjamin and Sirmans 1996; Riley 2001). In Minnesota, property taxes are a primary source of local road funding, and the ability of cities to raise revenue by other means is limited (Zhao *et al.* 2008). Provided that assessments of property value keep up with the real estate market, taxing

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land at a higher rate strengthens the connection between benefit from and payment toward transportation facilities. Even if overall property values fall due to broader economic factors, the value added by transportation improvements is still reflected in land prices.

Adopting a split-rate property tax as a value capture mechanism alters the cost of developing certain areas and affects developers' decisions on when, where and how much to build. The purpose of this paper is to simulate the development response to split-rate taxes in three sample cities in Minnesota. Conclusions from previous research on the economic effects of the tax are discussed along with a summary of previous applications. The data, methodology and results of the simulation are explained next, followed by a discussion of the conclusions and limitations.

## 2 Extent of Use

The most prominent applications of split-rate property taxes in the United States are in several cities in Pennsylvania. Beginning in 1913, the state allowed certain types of cities to assess land value separately from any structures on it and to levy tax on land at twice the rate of the tax on buildings. Pittsburgh and Scranton adopted the split-rate tax at that time. In the 1970s, the differential was allowed to increase, and the land rate in Pittsburgh was nearly six times the rate on buildings before the city reverted to a conventional single-rate property tax in 2001. Several smaller cities adopted a split rate more recently and continue to use it. Most had experienced economic downturns and population losses and used the split-rate tax to create an incentive for redevelopment and new construction in depressed areas.

A list of Pennsylvania cities taxing land and buildings at separate rates as of 2008 is given in Table 1. The land and building rates and the differential between them vary widely, partly due to the method of assessment used in Pennsylvania. The estimated market value at the last county-wide reassessment, or base year value, is multiplied by a predefined assessment ratio and then by the tax rate to calculate the amount of the tax. If the last reassessment was long ago or the assessment ratio is low, a higher tax rate can compensate. Several other states, including Maryland and New York, have investigated the feasibility of allowing certain municipalities to enact split-rate taxes (Hartzok 1997).

To date, split-rate taxation has been seen as a way to raise additional revenue or to facilitate development, rather than as a specific funding mechanism for transportation projects. Split-rate taxation is most applicable at the local level, because city

and county governments already levy property taxes, provide transportation facilities and have an interest in the regulation of land use. School districts in Pennsylvania are also permitted to use split-rate taxes, but only two currently do so. The ability of local governments in other states to levy split-rate property taxes depends on the basis of local taxing power, and might require a change in state law. Assessment procedures also differ by state, but the adoption of a split-rate tax would not require the use of Pennsylvania's base-year method.

## 3 Previous research

Past research on split-rate taxes has been focused largely on determining their effects on economic development, density and land value. Brueckner (1986) conducted a formal analysis, establishing that a split-rate tax increased the "level" of improvements per acre. In a general equilibrium model, DiMasi (1987) concluded that increasing the land rate relative to the building rate decreases rents and housing prices both overall and at each distance from the city center, and increases population density at all locations within the city. Resident welfare, in terms of affordable housing and wage level, was found to be optimal when land was taxed at three times the rate on improvements. Brueckner and Kim (2003) evaluated the spatial effects of the conventional property tax and found that when the elasticity of substitution between housing and other goods is high, a higher property tax causes denser development and more compact city size. When the elasticity is low, the higher tax decreases density and causes the city area to expand. They also considered replacement of the property tax with a revenue-neutral switch to a land tax and concluded that the city area would shrink under such a scenario. Song and Zenou (2006) also developed a model showing that increasing the property tax results in a smaller city area. Their research included an empirical analysis of several urban areas in the United States, which demonstrated that the cities with higher property taxes had developed more compactly.

A significant body of empirical research has been directed at the Pennsylvania applications and particularly on Pittsburgh, which has been the largest and most visible example. The most comprehensive study of split-rate property taxation in Pittsburgh was conducted by Oates and Schwab (1997). The research sought to explain the sharp increase in commercial construction in the 1980s compared to the previous two decades, while most similar cities in the region saw a substantial drop. In 1976, Pittsburgh began to raise its land tax: from twice the rate levied on buildings, the land tax rate ultimately reached nearly six times the building rate. However, there was

**Table 1:** Pennsylvania cities with split-rate property taxes, 2008.

City	Split-rate tax adopted	Land tax rate	Building tax rate	Tax rate ratio	Assessment base year	Assessment ratio
Aliquippa	1988	81.00	11.40	7.11	1982	50%
Allentown	1997	50.38	10.72	4.70	1991	50%
Altoona	2002	230.31	14.56	15.82	1958	75%
Clairton	1989	28.00	2.22	12.61	2002	100%
DuBois	1991	89.00	3.00	29.67	1989	25%
Duquesne	1985	19.00	11.47	1.66	2002	100%
Ebensburg	2000	27.50	7.50	3.67	2005	100%
Harrisburg	1975	28.67	4.78	6.00	2002	100%
Lock Haven	1991	96.79	16.97	5.70	1995	60%
McKeesport	1980	16.50	4.26	3.87	2002	100%
New Castle	1982	24.51	6.93	3.54	2003	100%
Scranton	1913	103.15	22.43	4.60	1973	100%
Steelton	2000	12.00	12.00	1.00	2002	100%
Titusville	1990	59.16	19.00	3.11	1971	75%
Washington	1985	82.63	3.50	23.61	1985	25%

*Source:* List of cities from [King and Nesbit \(2007\)](#); 2008 tax rates from the respective county assessment offices; base years and assessment ratios from the Pennsylvania State Tax Equalization Board.

also significant latent demand for office space that other cities did not experience, and beginning in 1980 a three-year abatement of the building tax was available for new construction. In light of these factors, [Oates and Schwab](#) concluded that raising the land tax was not the primary cause of the development increase, but that it was a significant enabling factor. The primary motivation for increasing the land rate was a revenue shortfall, and raising any other tax would have introduced disincentives that might have had an adverse effect on development. Other studies ([Bourassa 1987](#); [Cord 1983](#)) found some correlation between the split-rate tax and increased development, but determined that the effect was not consistent across property types and identified other conditions that could have sparked an increase in construction in the city. [Weir and Peters \(1986\)](#) determined that the higher rate on land still amounted to too low a carrying charge to factor into development decisions.

When [Bourassa \(1990\)](#) extended his Pittsburgh study to include two other locations, he found that the tax on buildings had a significant inverse relationship to the amount of new construction, but that increasing the tax on land had no significant effect. [Plassmann and Tideman \(2000\)](#) established that the tax differential had a statistically significant effect on construction value and on the number of building permits issued, but not on the value per permit. Although their model

did not evaluate land and building rates separately, their results indicate that increasing the tax differential (either by reducing the rate on buildings or by increasing the rate on land) leads to more construction. A more recent empirical study of Pennsylvania applications was conducted by [Banzhaf and Lavery \(2008\)](#), who separated density from dwelling size, noting that increasing the investment ratio of capital to land could result in larger housing units rather than more units in a given area. If the dwelling size effect were greater than the density effect, the result would be a decrease in development intensity and a more sprawling city. Their results indicated that the number of rooms per unit of land area increased in cities with a split tax, and the dwelling size effect was minimal. The density effect was greater, leading the researchers to conclude that adopting a split-rate tax would increase the number of housing units in a given area and lead to less sprawling development.

Researchers have also considered the administrative and political ramifications of split-rate taxation. [Hartzok \(1997\)](#) suggested that the transition should be gradual, with no more than 10–20 percent of the tax burden shifted from buildings to land in a given year. A revenue-neutral shift would prevent the public from falsely associating the split rate with a tax increase. Equally important to the success of a split-rate tax is the accurate, timely and fair assessment of land values. [Mills \(1998\)](#) argued that government lacks both the incentive and

the skill to predict the market value of a parcel of land under its optimal use. However, even if significant errors are made in land value assessment, economic efficiency gains are still likely with a split-rate tax as long as estimates of total property value are accurate (Chapman *et al.* 2009). One possible (but expensive) way for assessors to determine accurate land values would be to purchase property at market value, demolish any improvements and resell the vacant parcels (Anas 1998). If the tax is based on land values under optimal use, zoning and other restrictions limit the ability of property owners to use land more intensively. Finally, taxing land at a high enough percentage of its value might cause owners to simply abandon it, and the government usually has no interest in assuming the role of landlord.

#### 4 Data

A simulation was created to examine how development intensity would be affected by raising the tax on land and reducing the tax on buildings in three sample municipalities in the Twin Cities metropolitan area. The first data set considered for this analysis was the parcel file created by the Metropolitan Council<sup>1</sup> (the Twin Cities' regional planning organization), which includes land areas and estimated market values for land and buildings. Building areas are included for some, but not all, of the seven counties in the metropolitan area, and then only for residential properties; therefore, the sample size would have been severely restricted if building size were used as a dependent variable. Another limitation of the parcel data is that the values for land and buildings are estimates, and since no jurisdiction currently taxes them separately, there is no incentive for the assessors to emphasize the accuracy of the land values as long as the total property values are accurate.

In order to simulate separate tax rates for land and buildings, more reliable land valuations were needed. A hedonic pricing model for residential property in Hennepin County, which includes the three municipalities studied, had been created as part of a previous project (Iacono and Levinson 2009). The independent variables in that model were categorized according to whether they affected the value of the parcel (e.g. neighborhood factors, school quality, accessibility) or of the structure (e.g. age, number of bedrooms and bathrooms). Sources for the data used to create the model included single-family residential sales data from the Minnesota Multiple Listing Service (see Iacono and Levinson 2009), tract-level U.S. Census data (US Bureau of Census 2000), and school district

accountability data from the Minnesota Department of Education 2008. This model was used to determine the average land value in each census block as a proportion of total property value. The proportion was then applied to the total market value as estimated by the county assessors and given in the parcel data set. Because houses and the land on which they sit are almost always sold together, there is plenty of market data to corroborate these estimates and they are assumed to be reliable. In contrast, sales of vacant lots occur rarely enough that it is not always possible to use sales data for similar parcels to determine accurate land values independent of any structures. The resulting distribution of land values is shown in Figure 1.

The Metropolitan Council's major highways data set<sup>2</sup> was used to calculate variables representing the distance from the center of each block to the nearest Interstate and major highway. The distances to downtown Minneapolis (intersection of Nicollet Avenue and Seventh Street) and downtown Saint Paul (intersection of Seventh Street East and Cedar Street) were also computed. Accessibility measures, expressed in terms of the population and employment reachable within 30 minutes by car, were available for each 1990 Metropolitan Council transportation analysis zone (TAZ) from an earlier project (El-Geneidy and Levinson 2006).

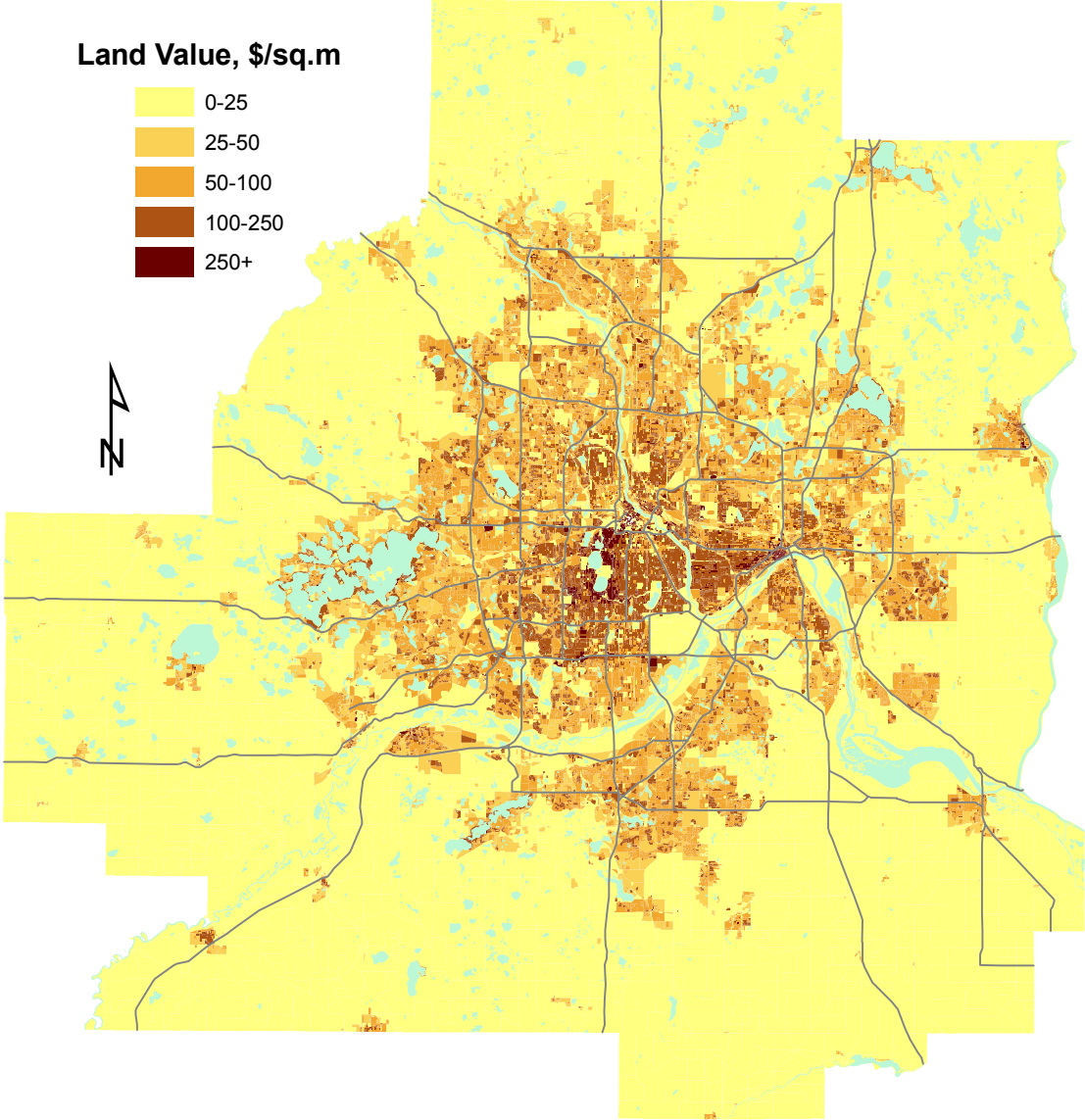
Since building size data was not available in the parcel data for most of the area, development intensity was modeled in terms of housing units and commercial floor space per unit of land area. Block-level housing unit counts were taken from 2000 U.S. Census data. Employment for each block in 2000 was determined by distributing retail, non-retail and total employment counts in each 2000 Metropolitan Council TAZ among the included blocks using proportions derived from 2005 data from the Longitudinal Employer-Household Dynamics program of the U.S. Census Bureau (Levinson *et al.* 2010). Block-level counts from this source were aggregated to the TAZ level, and each block was assumed to contain the same proportion of jobs in the TAZ in 2000 as in 2005.

Among the issues that arise from the level of aggregation used is that the city and county are not the only jurisdictions that levy property taxes. Additional taxes are levied by school districts, fire protection districts, watersheds and for other special purposes. In the process of deciding on the appropriate location and intensity of construction, a developer would consider the total property tax liability, not just that portion charged by the city. Any effect of a split municipal rate on development would be muted by the continuation of the conventional tax by other entities. Only city and county taxes were included in the analysis, but any effect of a split municipi-

<sup>1</sup> Available to governmental or academic interests from MetroGIS, <http://www.datafinder.org/catalog>.

<sup>2</sup> Available from MetroGIS, [www.datafinder.org/catalog](http://www.datafinder.org/catalog).





**Figure 1:** Regional distribution of land values ( $m^2$ ), calculated by applying the land proportion of total property value in each Census block from the hedonic model to assessors' estimates of total value.

pal rate on development would be muted by the continuation of the conventional tax by other entities. Also, aggregating the building values introduces the assumption that the average housing unit size and the building quality in terms of the average construction cost per unit remain fixed when the tax rates vary. This is not necessarily true, but is not unreasonable and would be consistent with previous empirical research (Banzhaf and Lavery 2008).

The employment count in each block was converted to developed floor area using conversion factors based on those that Hennepin County assumed in a fiscal impact model for development in its northwest corridor, which were 400 sq. ft. per retail job, 250 sq. ft. per professional job and 500 sq. ft. per industrial job. Because these are rough estimates and this analysis was conducted in metric units, 40, 25 and 50 square meters were used. Employment was divided into industrial and commercial categories proportionally using land areas taken from 2005 Metropolitan Council land use data. Agricultural land was included with industrial land to compute density, but was subtracted from the area used to apportion employment because it would otherwise have produced an unreasonably high number of industrial jobs.

The analysis assumed that land would remain in its current use, and that existing zoning regulations would remain in place, if a split-rate tax were adopted. Residential density was computed by dividing the number of housing units by the area in each block zoned for residential use, and nonresidential density by dividing developed floor area by the sum of commercial and industrial land area. The total area considered is less than the total land area in each block, as certain areas unlikely to develop—such as parks, cemeteries, vehicular rights-of-way and open water—were not included. Blocks with no residential area were not considered for the residential model, and blocks with no commercial or industrial development were left out of the nonresidential model. Blocks with no development or no parcel records were not used in either model.

## 5 Methodology

The demand to develop a parcel of land is assumed to depend on the parcel's accessibility and on the cost of development, including property taxes. Transportation access affects residential and nonresidential properties in different ways: a desirable business location is one that can be reached easily by both workers and customers, with retail businesses especially drawn to locations with high traffic and high visibility; a desirable residential location, on the other hand, is one with access to

jobs and services, but low impacts from negative externalities of transportation such as noise and air pollution. Because of these differences, and because the qualitative criteria involved in selecting a business location are different from those evaluated in a house purchase, two separate models were created.

Property tax rates for the year 2008 were obtained for each city and township in the metropolitan area from the web sites of the relevant county assessment offices. The blocks were then matched with municipalities using a geographic information system (GIS) to determine the tax rate effective in each block. A correlation was established between development density and municipal property tax rate, but since no local government in the area uses a split-rate tax, an alternate approach was necessary to separate the effects of the land and structures components of the tax. Variables were defined to represent the costs of land and residential and commercial development, including the tax. This allowed the land tax rate to be adjusted separately from the rate on buildings. To place the tax and the cost of acquiring land in the same temporal terms, the current values of city and county property taxes were computed using Equations 1 and 2.

$$V_{\tau_L} = \frac{\tau \sum V_L}{0.07} \quad (1)$$

$$V_{\tau_S} = \frac{\tau \sum V_L}{0.07} \quad (2)$$

The symbol  $\tau$  represents the tax rate;  $\tau_L$  and  $\tau_S$  denote the taxes on land and structures, respectively. In the base case using a conventional property tax,  $\tau_L = \tau_S = \tau$ . The seven percent discount rate was obtained from Office of Management and Budget recommendations (Office of Management and Budget 1992) for benefit-cost analyses of federal investments. Once the current values of city and county taxes were determined, the unit costs of land, housing and nonresidential floor area were computed for each block using Equations 3–5.

The cost of land  $C_L$  given by Eq. 3 is used in both models. Eq. 4 defines the residential development cost  $C_H$  per housing unit, and Eq. 5 gives the nonresidential development cost  $C_J$  per square meter of floor area. As with the conversion of employment to developed floor area above, the total structure value in each block is distributed proportionally using the land area in each block devoted to each use. The symbol  $A_D$  represents the total developed area,  $A_R$  is the area zoned for residential development and  $A_N$  is the area reserved for nonresidential uses.

$$C_L = \frac{\sum V_L + V_{\tau_L^{\text{city}}} + V_{\tau_L^{\text{county}}}}{\text{Land area}} \quad (3)$$

$$C_H = \frac{(\sum V_S + V_{\tau_S^{\text{city}}} + V_{\tau_S^{\text{county}}})(A_R/A_D)}{\text{Number of units}} \quad (4)$$

$$C_J = \frac{(\sum V_S + V_{\tau_S^{\text{city}}} + V_{\tau_S^{\text{county}}})(A_N/A_D)}{\text{Developed floor area}} \quad (5)$$

The residential model is given by Eq. 6 and the nonresidential model by Eq. 7. The dependent variables  $I_R$  and  $I_N$  indicate residential and nonresidential density, respectively, in terms of housing units per square meter of land and developed floor area per square meter of land. The distances  $d$  to the Minneapolis and Saint Paul central business districts and to the nearest major highway centerline are straight lines.  $C_L$ ,  $C_H$  and  $C_J$  are the cost variables, including the tax rates, as calculated by Eqs. 3, 4 and 5. If the costs for developing residential and nonresidential properties were independent, some cross-elasticity might be observed, but the way they are defined results in collinearity. Accessibility represents the population and number of jobs reachable within 30 minutes by car. Distances were calculated in kilometers and costs in thousands of dollars. Summary statistics for the residential model are given in Table 2 and for the nonresidential model in Table 3.

$$\ln(I_R) = f(C_L, C_H, d_{\text{downtowns}}, d_{\text{highway}}, \text{Accessibility}) \quad (6)$$

$$\ln(I_N) = f(C_L, C_J, d_{\text{downtowns}}, d_{\text{highway}}, \text{Accessibility}) \quad (7)$$

Tax rates for prediction purposes were calculated assuming revenue neutrality using Eqs. 8 and 9, a system similar to that used by [Cho et al. \(2008\)](#). The levels of revenue raised by existing municipal property taxes were taken as fixed, necessary and optimal for provision of public services in the cities examined.

Equation 8 calculates the revenue  $R$  generated by the existing property tax at rate  $\tau$  on the land  $L$  and structures  $S$  on all parcels in each city. The proposed land tax rate  $\tau_L$  and structure tax rate  $\tau_S$  together must yield this amount. The variable  $\alpha$  in Equation 9 represents the differential between land and building rates and must be input. To test a variety of rate differentials similar to those currently in use in Pennsylvania,  $\alpha$  values of 2, 5, 10 and 20 were tested. The two equations together were then used to determine revenue-neutral test rates for land and buildings.

$$R = \tau(L + S) = \tau_L L + \tau_S S \quad (8)$$

$$\tau_L = \alpha \tau_S \quad (9)$$

## 6 Results

The results from the residential regression are displayed in Table 4 and the results from the nonresidential regression in Table 5. In the residential model, the parameters on all variables are statistically significant at the 99 percent confidence level. The signs on the cost variables are as expected, with increased density associated with higher land costs and lower structure costs. The expected negative signs also appear on the parameters for the distance and accessibility variables. Residents are expected to concentrate in areas with access to large numbers of jobs and commercial development, and in areas with less access to population that could represent competition for those opportunities.

In the nonresidential model, the cost variables and the distances to the downtowns are statistically significant at the 99 percent confidence level. As in the residential model, the land and building cost variables are both significant and display the expected signs. Although they are not statistically significant, the parameters on the other variables display the anticipated signs, except the accessibility to population. At the census block level, population and employment are highly and inversely correlated, due to the Census Bureau's goal of making blocks as homogenous as possible.

The equations resulting from the regressions were then used to predict the effects of a split-rate tax in Minneapolis, Richfield and Bloomington. These municipalities are adjacent and were chosen to represent the existing development intensity typical in a central city, an inner-ring suburb and an outer suburb. The revenue-neutral tax rates calculated for the analysis using the procedure explained above are displayed with the average predicted intensity changes for each city in Table 6. Predicted changes are displayed as a percentage of the modeled intensity under the existing tax rates. The percentages shown are averages of the projected density increase in each census block in each city, weighted by the area in the block devoted to residential or nonresidential development.

The spatial distribution of the predicted increases in development intensity for residential property is presented in Figures ?? and ?? and for nonresidential development by Figures ?? and ?? for land : structures tax ratios of 2 : 1 and 5 : 1. The intensity increase is most pronounced in Minneapolis, where the necessary tax rate on land is highest. Within Minneapolis, land values are higher in the southern half of the city, so this is where the greatest increase in residential density is

**Table 2:** Summary statistics for census blocks included in the residential model.

Variable	Mean	Std. Dev.	Median	Min	Max
City tax rate	34.71	12.13	32.53	3.98	102.82
County tax rate	35.86	6.28	38.57	25.20	44.02
ln housing units per unit land area (m <sup>2</sup> )	-7.38	1.33	-7.19	-14.69	4.15
Land cost per square meter (×\$1000)	1.09	1.00	0.90	0.00	31.55
Structure cost per unit (×\$1000)	765.96	1466.14	538.86	0.00	55 355.58
Distance to downtown Minneapolis (km)	19.93	11.96	18.14	0.10	63.56
Distance to downtown St. Paul (km)	22.93	13.49	20.77	0.09	75.57
Distance to nearest highway (km)	1.75	2.08	1.11	0.00	17.36
ln population accessible in 30 min	13.96	0.69	14.24	10.68	14.63
ln employment accessible in 30 min	13.45	0.88	13.81	9.38	14.16

*Note:* Costs are present values of perpetual ownership; distances are calculated from block centroids.

**Table 3:** Summary statistics for census blocks included in the nonresidential model.

Variable	Mean	Std. Dev.	Median	Min	Max
City tax rate	35.66	12.15	31.97	3.98	102.82
County tax rate	36.37	6.27	38.57	25.20	44.02
ln floor area per unit land area (m <sup>2</sup> )	-2.39	2.20	-2.37	-11.48	14.20
Land cost per square meter (×\$1000)	1.29	3.54	0.75	0.00	101.86
Structure cost per square meter (×\$1000)	17.97	69.63	3.77	0.00	3270.83
Distance to downtown Minneapolis, (km)	18.60	11.97	16.40	0.11	61.66
Distance to downtown St. Paul, (km)	21.69	13.77	19.38	0.06	74.03
Distance to nearest highway, (km)	1.33	1.90	0.75	0.00	16.08
ln population accessible in 30 min	14.03	0.68	14.30	10.68	14.63
ln employment accessible in 30 min	13.53	0.84	13.89	9.38	14.16

*Note:* Costs are present values of perpetual ownership; distances are calculated from block centroids.

shown. Nonresidential increases follow a less obvious pattern, but concentrations are evident in downtown Minneapolis and along corridors such as Hennepin and Nicollet Avenues, especially when the split becomes larger. As the signs on the land and building cost parameters indicate, a ratio of 5 : 1 results in greater density than a ratio of 2 : 1. The resulting maps for ratios of 10 : 1 and 20 : 1 are not displayed but indicate still greater development intensity.

This model represents a partial equilibrium state of development in the cities analyzed. It demonstrates the supply of development that property owners would prefer to provide within the city limits given changes in the property tax system, but does not account for demand from tenants for more leasable space. Presumably, demand would increase with supply—to a point. Compelling builders to provide more units in

order to cover increased land taxes and take advantage of the reduced cost of building would create a market favorable to renters. However, whether demand would increase enough to justify the predicted density shown in the figures is not at all certain. Moreover, whether the influx of businesses and residents would come from elsewhere within the metropolitan area or from outside it remains unknown.

The model does not consider the cost of building in other cities when predicting the effect of tax changes in a specific city on development density. If only a few cities within a larger metropolitan region were to adopt a split-rate tax and then see a spike in building, that effect might erode as neighboring cities followed their example. The scale of development in downtown Minneapolis is unique within the metropolitan area, but typical levels of new construction in Richfield and



**Table 4:** Residential model results.

Variable	Parameter	Std. Error	t Statistic	Sig.
Intercept	-4.188 12	0.483 45	-8.66	**
Land cost per square meter	0.468 42	0.006 41	73.13	**
Structure cost per unit	-0.000 282 7	0.000 003 65	-77.53	**
Distance to downtown Minneapolis	-0.013 78	0.001 35	-10.20	**
Distance to downtown St. Paul	-0.016 03	0.000 756 9	-21.18	**
Distance to nearest highway	-0.147 86	0.003 16	-46.78	**
ln population accessible in 30 min.	-0.581 63	0.063 38	-9.18	**
ln employment accessible in 30 min.	0.411 1	0.042 74	9.62	**

Note: Dependent variable =  $\ln(\text{housing units per m}^2)$ .  $R^2 = 0.51$ ,  $n = 31\,511$ . \*\* = significant at 99% confidence level.

**Table 5:** Nonresidential model results.

Variable	Parameter	Std. Error	t Statistic	Sig.
Intercept	0.122 13	2.053 22	0.06	
Land cost per square meter	0.090 38	0.006 26	14.44	**
Structure cost per square meter	-0.011 4	0.000 308 73	-36.92	**
Distance to downtown Minneapolis	-0.041 96	0.005 09	-8.24	**
Distance to downtown St. Paul	-0.015 42	0.003 12	-4.95	**
Distance to nearest highway	-0.005 1	0.013 42	-0.38	
ln population accessible in 30 min.	-0.346 14	0.276 07	-1.25	
ln employment accessible in 30 min.	0.262 42	0.182 54	1.44	

Note: Dependent variable =  $\ln(\text{floor area (m}^2) \text{ per land area (m}^2))$ .  $R^2 = 0.27$ ,  $n = 7\,679$ . \*\* = significant at 99% confidence level.

Bloomington could be replicated in any of several other suburbs. Any resulting density change would in turn affect the optimal distribution of land uses within the city, as well as land values. If, for example, commercial development were to intensify more quickly than residential development, zones could be shifted from commercial to residential uses. The change in land value produced by a higher land tax may necessitate adjustments to the tax rates until a revenue-neutral equilibrium is reached.

Future research should address several limitations of the present analysis in order to produce a better model. First and foremost, the effects of the tax should be separated from the effects of land and structures pricing. This would illustrate more directly the effects of changing tax structure and also allow for variation in construction quality and dwelling size. If building size data were made available at the parcel level, the assumption that land will remain in its current use could be relaxed, and the residential and nonresidential models could

be combined. However, some level of aggregation would still be necessary for prediction purposes, since the process of developing each parcel is unique, and accurately predicting the future of any specific parcel is not feasible. Another improvement to the model's accuracy could be made by including the total property tax liability, rather than just the city and county rates. Finally, development intensity could be evaluated as a proportion of some maximum allowable value, since zoning laws limiting the intensity of land use could remain in place if a split-rate tax were adopted.

## 7 Conclusion

Split-rate property taxes are more effective than conventional property taxes at capturing value accruing to a property from external sources such as transportation access, and also reduce taxes on the portion of value created by the efforts of the owner. The owners of parcels adjacent to transportation facil-

**Table 6:** Predicted changes in development intensity.

City	Ratio	Land Rate	Bldg. Rate	Pred. Change (Residential)	Pred. Change (Nonresidential)
Minneapolis	1:1	56.286	56.286	—	—
	2:1	65.523	32.761	16.57%	5.89%
	5:1	72.678	14.536	35.54%	24.24%
	10:1	75.424	7.542	47.45%	48.84%
	20:1	76.876	3.844	56.20%	73.30%
Richfield	1:1	37.910	37.910	—	—
	2:1	44.165	22.082	7.67%	4.01%
	5:1	49.017	9.803	14.04%	7.56%
	10:1	50.880	5.088	16.59%	9.03%
	20:1	51.866	2.593	17.97%	9.84%
Bloomington	1:1	31.966	31.966	—	—
	2:1	37.424	18.712	6.48%	2.64%
	5:1	41.696	8.339	11.92%	5.52%
	10:1	43.345	4.335	14.11%	6.97%
	20:1	44.220	2.211	15.30%	7.84%

*Note:* The rates as shown apply not to market value but to tax capacity as defined by Minnesota Statute 273.13. Tax capacity of residential property is defined as one percent of the first \$500,000 in market value and 1.25 percent of remaining value. Tax capacity for commercial property is 1.5 percent of the first \$150,000 and two percent of remaining value.

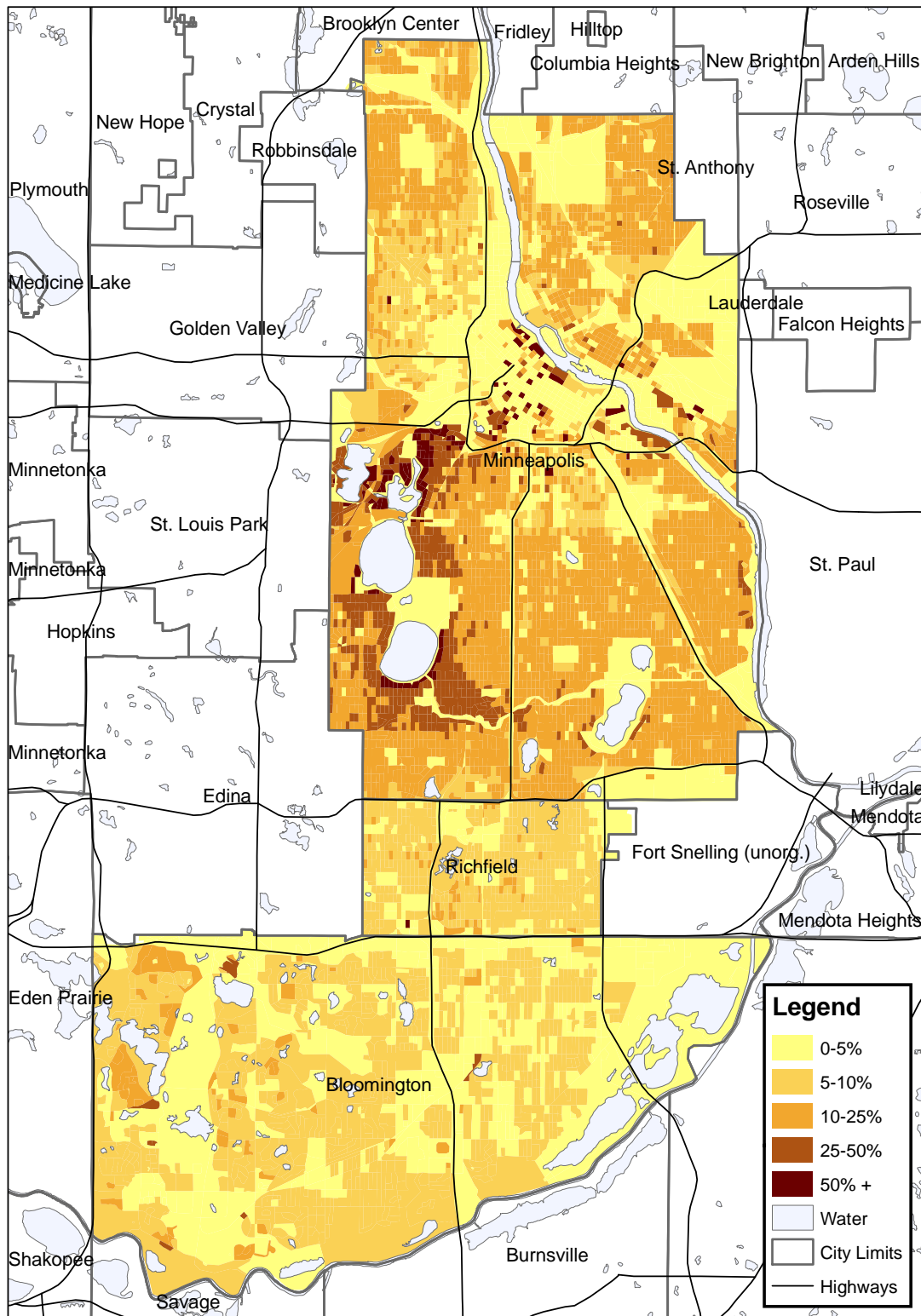
ities would pay a larger share of the costs of infrastructure improvements than the owners of distant properties that would benefit less. As long as assessments were kept up to date, the increased value would be captured automatically in the property tax bill and there would be no need to assess additional fees. The split-rate tax is perhaps the broadest value capture strategy because it applies throughout a jurisdiction and reflects changes in land value generated by sources other than transportation improvements. If the goal is to leave other value untouched, a more local mechanism may be preferred.

By influencing developer incentives, a split-rate property tax would be likely to lead to more dense development. The higher tax on land would require developers to build more in order to recoup their expenses, while the lower tax on improvements would remove a disincentive for building. The results of the models described in this paper indicate that these effects would obtain for both residential and nonresidential development, in the central city as well as in the suburbs. Raising the tax on land has a greater effect than reducing the tax on buildings in both models. The predicted increase in density is greatest where the property tax rate is high, where land value is high and where existing density is low relative to land value. In

practice, however, the effects would be contingent on the demand from tenants for more development and on regulations governing land use. Because the value of land independent of structures is difficult to determine, the largest technical challenge to split-rate taxation is the accurate assessment of land value.

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**Figure 2:** Predicted change in residential density in terms of housing units per unit land area by census block, 2 : 1 tax rate ratio.

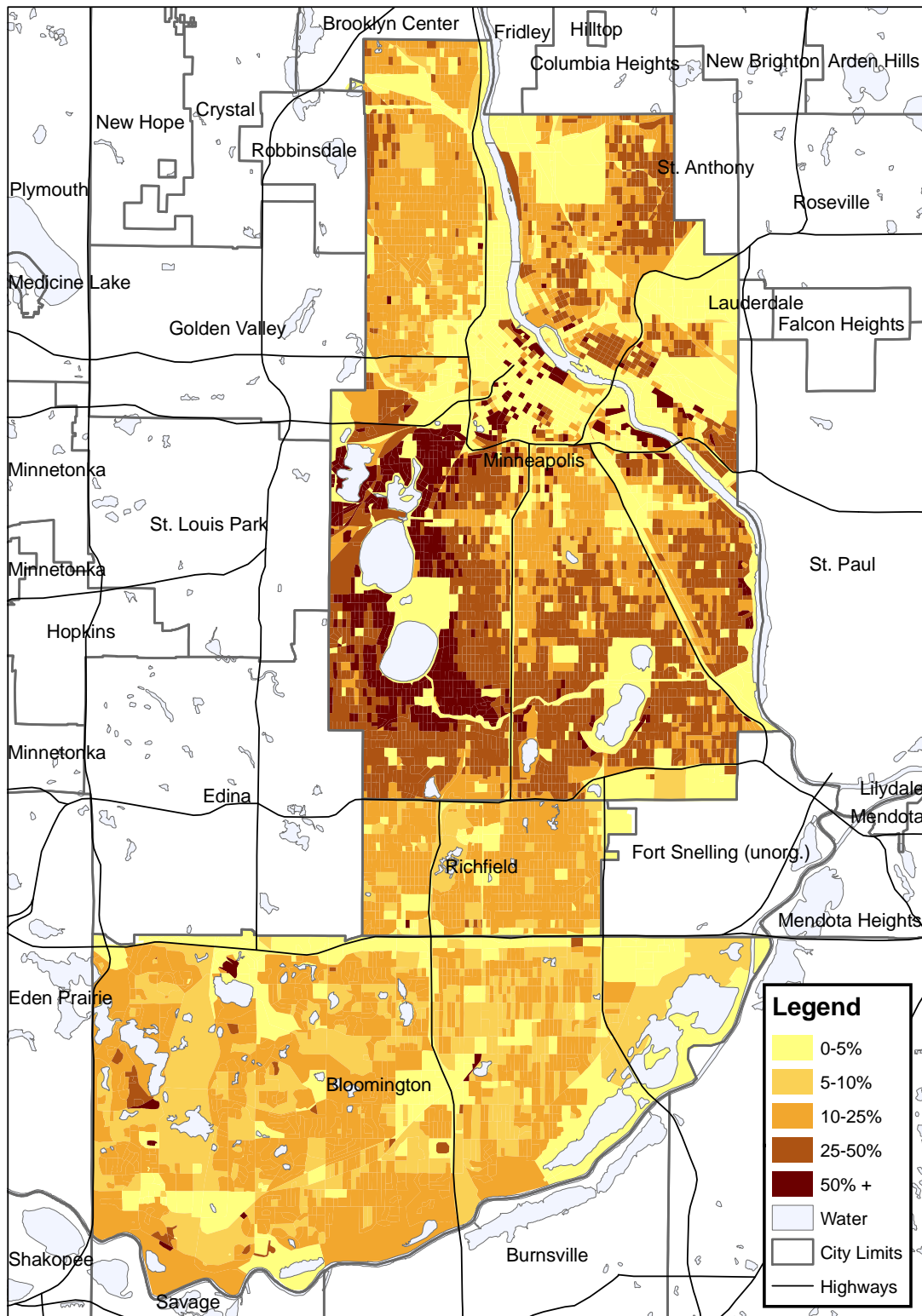
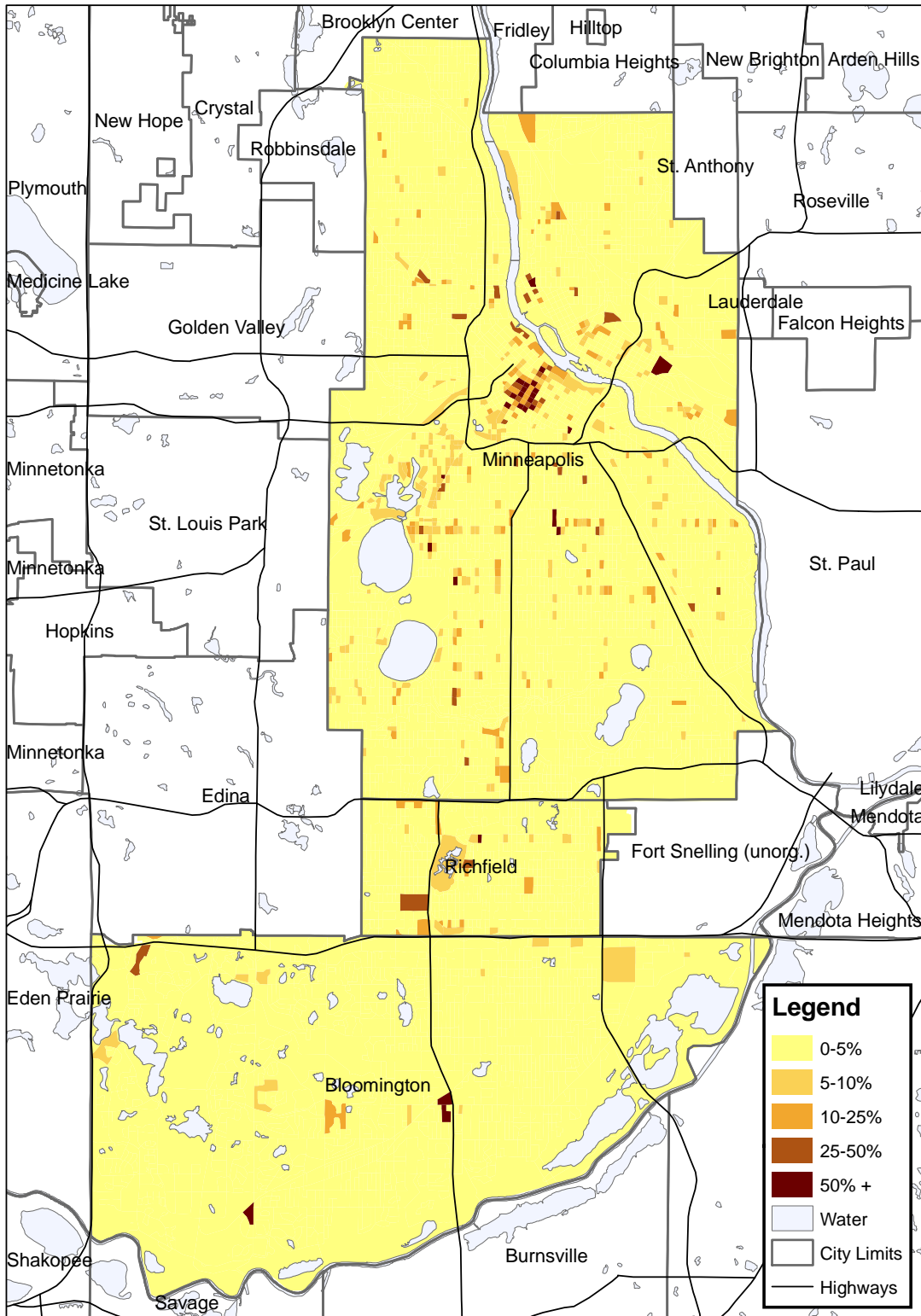
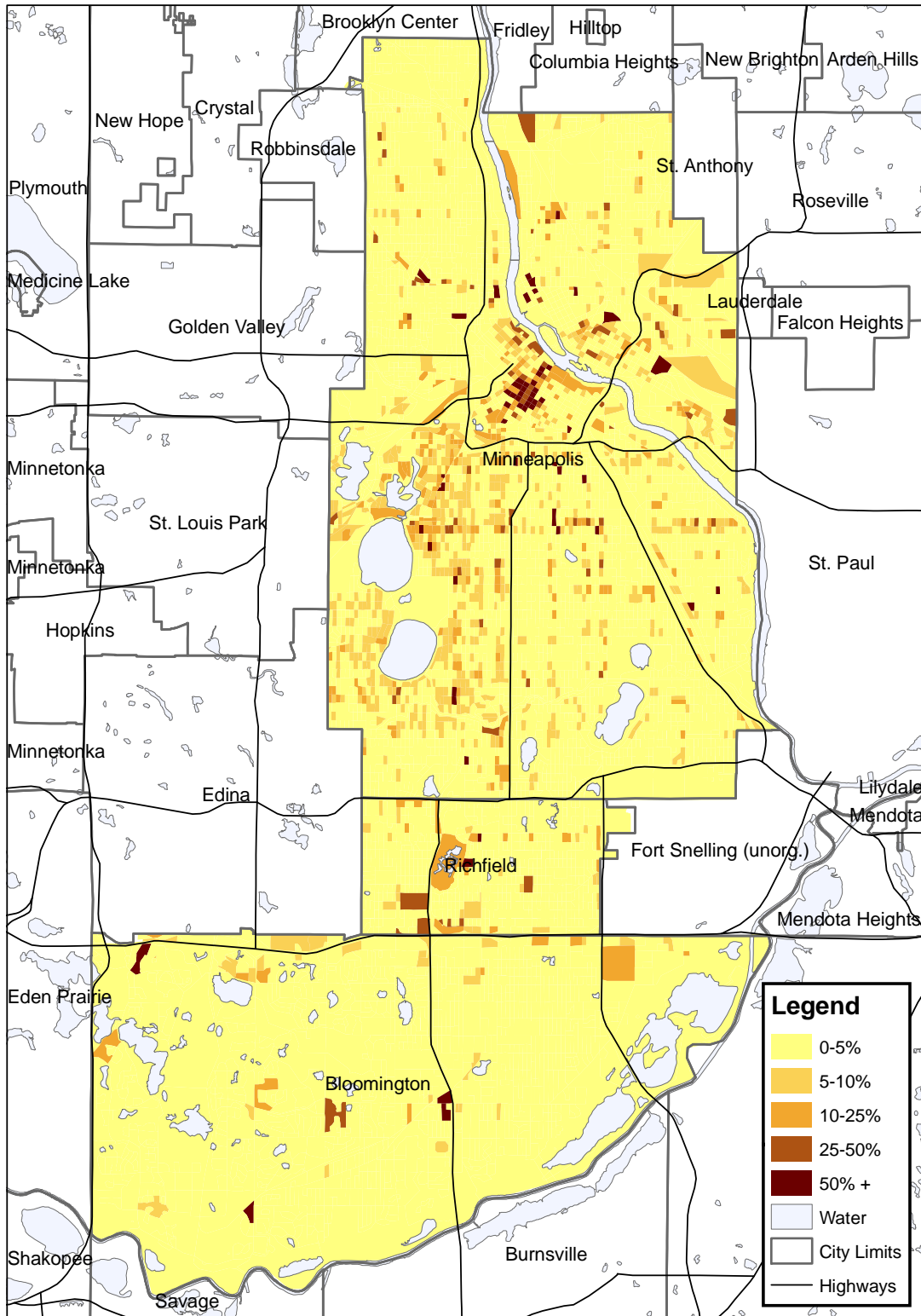


Figure 3: Predicted change in residential density in terms of housing units per unit land area by census block, 5 : 1 tax rate ratio.





**Figure 4:** Predicted change in nonresidential density in terms of developed floor area per unit land area by census block, 2 : 1 tax rate ratio.



**Figure 5:** Predicted change in nonresidential density in terms of developed floor area per unit land area by census block, 5 : 1 tax rate ratio.

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