CHAPTER 1

Spatial Models of Travel Behavior and Land Use Restriction

1.1. Introduction

Location of economic activity has always been an important aspect of regional economics. Spatial proximity plays a key role in many decisions made by individuals when it comes to weighing the benefits and costs of purchase decisions, allocation of resources, and other economic behavior in general. Transportation choices are particularly affected by location, and distances between origins and destinations undoubtedly influence the travel decisions among individuals.

While the study of regional economics and regional science in general has been around for a long time, the development of formal econometric techniques to address location is a more recent development in the field. Of particular importance to the field of spatial econometrics is the treatment of spatial dependence (spatial autocorrelation) and spatial heterogeneity (spatial structure). Spatial dependence and spatial heterogeneity are important in applied economic models because the presence of these phenomena may invalidate or bias mainstream results. In addition, these issues have been largely ignored in the mainstream literature. (Anselin, 1988)

This chapter focuses on consumer transportation mode choice in a spatial context. Behavioral models of transportation choice follow the random utility model addressed in the previous chapter. In this chapter, the travel behavior model is adapted from the preceding chapter to incorporate spatial dependence and spatial heterogeneity to test whether the results are significantly different from the standard econometric model

of transportation mode choice where space is dealt with informally. It is particularly important to investigate the presence of spatial dependence and heterogeneity in regards to land use restrictions because each individual faces a unique set of transportation choices based on their residential location and the proximity of this residential location to available goods, service, recreation, transportation, and employment opportunities.

1.2. Methodology: The Spatial Econometric Approach

Spatial econometrics differentiates itself from mainstream econometric approaches by applying formal spatial modeling best summarized in Luc Anselin's pioneering work on the topic:

> "I will consider the field of spatial econometrics to consist of those methods and techniques that, based on formal representation of the structure of spatial dependence and spatial heterogeneity, provide the means to carry out the proper specification, estimation, hypothesis testing, and prediction for models in regional science." (Anselin, 1988)[p.10]

1.2.1. Spatial Effects.

Regional science and regional economics inherently deal with issues related to human behavior across space, cities, and regions. The term *spatial econometrics* and its designation as a distinct branch of econometrics dates back to the seminal work of Paelinck and Klaassen (1979) that collected a growing body of literature in the regional sciences that attempted to formally deal with the problems inherent in modeling spatial data in the context of regional econometric models. The primary characteristics that delineate the field according to Paelinck and Klaassen (1979) and summarized by Anselin (1988)[p.7] are:

- the role of spatial interdependence in spatial models

- the asymmetry in spatial relations
- the importance of explanatory factors located in other spaces
- differentiation between ex post and ex ante interaction
- explicit modeling of space

While it is possible to measure and model spatial data using standard econometric techniques by including variables in the model that have a spatial nature to their measurement (as I have done in the previous chapter, i.e. the percentage of zoning types within as distance from a respondents residence), the distinction to be made here is that spatial econometrics formally deals with specific spatial aspects of the data at hand that preclude the use of traditional econometric techniques, and more particularly, address spatial dependence and spatial heterogeneity (Anselin, 1988; LeSage and Pace, 2009).

Spatial dependence addresses the lack of mutual independence across observations in cross-sectional data-sets and is often referred to as spatial autocorrelation following the path-breaking work of Cliff and Ord (1968, 1973). In essence, addressing spatial dependence is the development of formal mathematical specifications of economic models that address Tobler's first law of geography, that "everything is related to everything else, but near things are more related than distant things."(Tobler, 1970)[p.236] Spatial dependence is estimated by the relative location of one observation in the dataset to another, with an emphasis on the effect of distance between observations. Spatial dependence is caused by a variety of measurement errors, by spatial spill-over effects or spatial externalities (Anselin, 1988), by spatially autocorrelated variables (Fingleton, 1999), or any situation in which the covariance of observations across geographical space is not equal to zero (Anselin, 2001).

Spatial Heterogeneity is the "lack of stability over space of the behavioral or other relationship under study. More precisely, this implies that functional forms and parameters

vary with location and are not homogeneous throughout the data set."(Anselin, 1988)[p.9] This type of econometric model addresses these issues by formally modeling the variation in parameters across space to address the heterogeneous effect an independent variable may have in different locations. More importantly, when spatial dependence and spatial heterogeneity are present in the data generating process and not explicitly modeled, the results of mainstream econometric techniques may be biased, inefficient, or both Anselin (1988); LeSage and Pace (2009). Spatial econometric techniques address spatial processes within the data generating process and are generally preferred when spatial processes are at work in the data.

1.2.2. Measuring Spatial Dependence. The global measure of spatial autocorrelation is Moran's I (Moran, 1950)

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{1}$$

and Geary's C (Geary, 1954)

$$C = \frac{(n-1)}{2\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - x_j)^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{2}$$

Moran's I ranges between 0 and 1, with 1 being the absence of spatial autocorrelation, and 0 indicating strong spatial dependence of the observed variable Moran (1950). Geary's C ranges between 0 and 2, with values less than 1 demonstrating increasing positive spatial autocorrelation and values greater than 1 indicating increasing negative spatial autocorrelation Geary (1954). Moran's I is a global measure of spatial autocorrelation, while Geary's C indicates more local spatial autocorrelation. Table 1.1 shows that Moran's I is close to 0 for many of the variables under using the binary row standardized spatial weights

matrix, indicating global autocorrelation, with slightly less indication of autocorrelation using the inverse distance row standardized spatial weights matrix. Geary's C statistics also show local positive autocorrelation under both spatial weights matrices. This result is an indication that spatial dependence may have a significant presence in the underlying data generating processes, and the dataset may exhibit spatial processes including clustering of socioeconomic traits, political zoning boundary determination, and transit network design.

TABLE 1.1. Moran's I and Geary's C Statistics

Dependent Variable: Non-auto Transportation Mode = 1				
Variable	Moran's I	Moran's I (1/d)	Geary's C	Geary's C (1/d)
HH size	0.084	0.449	0.915	0.555
HH vehicles	0.065	0.427	0.934	0.569
HH bikes	0.072	0.477	0.935	0.527
Male	0.000	−0.228	1.000	1.229
Age	0.035	0.277	0.962	0.734
Income (000s)	0.083	0.420	0.918	0.581
College education	0.070	0.175	0.931	0.829
Employed	0.011	0.088	0.988	0.902
Tour distance	0.024	0.081	0.979	0.935
Tour crosses highway	0.039	0.117	0.963	0.876
Miles bike lanes < 1 M.	0.838	0.953	0.156	0.048
Miles of bus routes < 0.5 M.	0.639	0.903	0.354	0.111
Bus stops < 0.5 M.	0.654	0.905	0.344	0.111
Rail stops < 0.5 M.	0.473	0.846	0.530	0.173
Miles of rail lines < 0.5 M.	0.687	0.899	0.301	0.101
Intersections with 0.5 M	0.475	0.836	0.496	0.150
CBG population/sq. mile	0.423	0.758	0.590	0.244
CBG jobs/sq. mile	0.179	0.629	0.854	0.361
Work stops	−0.000	0.029	1.004	0.964
Shopping stops	0.006	0.083	0.996	0.907
Social stops	0.001	0.084	1.006	0.912
Residential Low Density, 0-1/4 mile	0.548	0.847	0.449	0.154
Residential Medium Density, 0-1/4 mile	0.392	0.808	0.580	0.190
Residential High Density 0-1/4 mile	0.520	0.820	0.486	0.186
Business Low Density 0-1/4 mile	0.175	0.697	0.819	0.288
Business High Density 0-1/4 mile	0.397	0.815	0.579	0.187
Industrial 0-1/4 mile	0.269	0.698	0.667	0.253
Residential Low Density, 1/4-1/2 mile	0.681	0.899	0.315	0.103
Residential Medium Density, 1/4-1/2 mile	0.649	0.895	0.326	0.104
Residential High Density 1/4-1/2 mile	0.658	0.880	0.360	0.125
Business Low Density 1/4-1/2 mile	0.355	0.778	0.667	0.224
Business High Density 1/4-1/2 mile	0.527	0.848	0.454	0.148
Industrial 1/4-1/2 mile	0.469	0.797	0.449	0.167
Residential Low Density, 1/2-1 mile	0.767	0.931	0.218	0.067
Residential Medium Density, 1/2-1 mile	0.749	0.941	0.223	0.061
Residential High Density 1/2-1 mile	0.773	0.918	0.239	0.082
Business Low Density 1/2-1 mile	0.623	0.897	0.392	0.113
Business High Density 1/2-1 mile	0.670	0.910	0.312	0.094
Industrial 1/2-1 mile	0.583	0.866	0.338	0.112

Significance tests for the Moran's I and Geary's C test statistics for normalized variance are given in table Table 1.2 and follow the method proposed in **?**. All test statistics are significant at the 1 percent level, indicating the presence of spatial dependence and confirming the statistical significance of the Moran's I and Geary's C results in Table 1.1. This result is not surprising, considering that spatial segregation of land use is one of the objectives of zoning laws, and that socioeconomic segregation is a widely accepted phenomenon that is the subject of many areas of study.

TABLE 1.2. Moran's I and Geary's C: Standard Deviate

Dependent Variable: Non-auto Transportation Mode = 1				
Variable	Moran's I	Moran's I (1/d)	Geary's C	Geary's C (1/d)
HH size	53.079	56.093	37.218	49.622
HH vehicles	41.260	53.307	28.919	48.117
HH bikes	45.403	59.598	28.836	52.751
Male	0.261	−28.438	0.168	−25.502
Age	22.483	34.605	16.752	29.723
Income (000s)	52.479	52.507	36.080	46.728
College education	44.454	21.941	30.366	19.067
Employed	7.162	11.041	5.339	10.951
Tour distance	15.275	10.190	9.036	7.242
Tour crosses highway	24.803	14.681	16.448	13.829
Miles bike lanes < 1 M.	528.773	119.046	371.580	106.212
Miles of bus routes < 0.5 M.	403.656	112.789	284.635	99.108
Bus stops < 0.5 M.	412.716	113.106	289.094	99.160
Rail stops < 0.5 M.	298.554	105.717	206.788	92.285
Miles of rail lines < 0.5 M.	433.986	112.351	308.073	100.255
Intersections with 0.5 M	299.621	104.511	222.169	94.857
CBG population/sq. mile	267.142	94.691	180.528	84.296
CBG jobs/sq. mile	113.235	78.594	64.408	71.255
Work stops	−0.056	3.612	−1.982	4.065
Shopping stops	3.963	10.401	1.631	10.335
Social stops	0.467	10.561	−2.720	9.843
Residential Low Density, 0-1/4 mile	346.002	105.805	242.614	94.380
Residential Medium Density, 0-1/4 mile	247.224	100.948	184.840	90.343
Residential High Density 0-1/4 mile	328.353	102.414	226.219	90.739
Business Low Density 0-1/4 mile	110.453	87.136	79.498	79.399
Business High Density 0-1/4 mile	250.832	101.782	185.469	90.666
Industrial 0-1/4 mile	169.894	87.213	146.850	83.360
Residential Low Density, 1/4-1/2 mile	429.751	112.275	301.907	100.022
Residential Medium Density, 1/4-1/2 mile	409.493	111.825	296.920	99.980
Residential High Density 1/4-1/2 mile	415.353	110.010	281.861	97.544

Business Low Density 1/4-1/2 mile	224.098	97.162	146.821	86.568
Business High Density 1/4-1/2 mile	332.942	105.952	240.557	95.082
Industrial 1/4-1/2 mile	295.861	99.529	242.658	92.959
Residential Low Density, 1/2-1 mile	484.470	116.358	344.550	104.048
Residential Medium Density, 1/2-1 mile	472.624	117.574	341.991	104.688
Residential High Density 1/2-1 mile	487.645	114.761	335.275	102.359
Business Low Density 1/2-1 mile	393.088	112.075	267.961	98.894
Business High Density 1/2-1 mile	422.850	113.728	303.050	101.034
Industrial 1/2-1 mile	368.325	108.178	291.468	99.009

These test results justify using spatial econometric modeling techniques to address the spatial dependence and heterogeneity that may be present in the data. I focus on three specifications of spatial models, the spatial autoregressive model (SAR) which addresses spatial dependence, the spatial error model (SEM) which addresses spatial heterogeneity, and the spatial Durbin model (SDM) which simultaneously addresses spatial dependence and spatial heterogeneity. As suggested by **?** I also estimate each of the models using the two most common row standardized spatial weights matrices and use a Lagrange multiplier test to determine the which spatial weight matrix best fits the data. The two spatial weights matrices considered are the binary and inverse distance spatial weight matrices with row standardization.

1.2.3. The Spatial Weights Matrix. At the center of spatial econometrics is defining spatial association amongst observations (Anselin, 1988; Arbia, 2006; Anselin, 2010). The typical convention is to define spatial connectedness through the use of a symmetric matrix **W** of dimensions *NxN* whose strictly non-negative elements W_{ij} indicate the spatial connectedness between units i and j. The pioneering work of Moran (1950) and Geary (1954) first developed the notion of a binary weight matrix where element W_{ij} was assigned a value of 1 if two observational units were contiguous and thus determined to exhibit influence on each other and 0 otherwise. Cliff and Ord (1973, 1981) extended this concept

to include a more general specification of the spatial weight matrix by incorporating inverse distance and negative exponentials of distance as the measure of spatial influence rather than the binary specification. The spatial weight matrix is often row standardized so that each row sums to 1. Each element of a row standardized spatial weights matrix $\mathbf{W}^s$ is then calculated as

$$w_{ij}^s = \frac{w_{ij}}{\sum_j w_{ij}} \tag{3}$$

The decision to standardize the spatial weights matrix is not at all clear from the literature, and decisions on how to form the spatial weights matrix are generally determined by a priori assumptions made by the researcher in the context of each study. Anselin (1988) argues that in certain cases, such as inverse distance, the standardization of the spatial weights matrix may eliminate the economic interpretation of the results. However, the consensus is that the standardization of the spatial weights matrix is the preferable approach to avoid magnitude complications amongst variables and avoid certain spatially weighted variables dominating the results of spatial model (LeSage and Pace, 2009).

The spatial weights matrix was originally developed in the context of areal units and each areal unit was said to be neighbors and therefore exert influence on other observations if the two observational units shared a common border or some similar derivation of this measure **?**. When the observational unit is in the form of points in space rather than areal units (as the data in this study is), neighbors are instead identified on the basis of distance. Two spatial units i and j are considered neighbors if $0 \leq d_{ij} \leq D$ with d_{ij} a distance measure between points and D the bandwidth after which interaction between observations is considered non-existent and that element of the weights matrix is assigned

a 0 weight (Anselin, 1988). This does not preclude spatial effects of more distant neighbors being present, but influence is modeled as a higher order recursive effect on any given observation through the spatial dependence parameter ρ on the dependent variable in spatial autoregressive and spatial durbin models, as well as through the effect spatially weighted independent variables have on the dependent variable in spatial durbin models.

1.2.4. The Spatial Autoregressive Model. The spatial autoregressive model (SAR) formally estimates the presence of spatial dependence by incorporating a spatially lagged dependent variable on the right hand side of the regression equation **?**. Thus, observations of the dependent variable are influenced by other observations of the dependent variable nearby. In the context of the present study, the SAR model is a way of controlling for the influence of neighboring survey respondents' transportation mode choices on the observational unit under study. In the binomial context, the choice variable observed (transportation mode = non-auto) depends on the underlying utility of the choice indicator observed. The underlying latent variable $y_i^* = U_{1i} - U_{0i}$ and follows a normal distribution in the probit model estimation. The general SAR model in a binomial context can be formally stated as:

$$
\begin{aligned}
y_i^* &= \rho W y + X\beta + \varepsilon \\
\varepsilon &\sim N(0, \sigma^2 I_n) \\
y_i &= 1, \quad \text{if} \quad y_i^* \geq 0 \\
y_i &= 0, \quad \text{if} \quad y_i^* < 0
\end{aligned}
\tag{4}
$$

where $y_i = 1$ if the binomial choice is observed, and 0 otherwise, $\mathbf{W}$ is the spatial weights matrix, y is a binomial vector of all dependent variables for the data set, ρ is an estimated parameter of spatial decay of autocorrelation between observations, $\mathbf{X}$ is a matrix of independent variables, and β is a vector of estimated coefficients. The latent utility construct implies that $Pr(y_i = 1) = Pr(U_{1i} \geq U_{0i}) = Pr(y_i^* \geq 0)$.(LeSage and Pace, 2009)

Typically, the SAR model is used to adjust for dependent variables that have a direct effect on the realization of the dependent variable in close proximity. The classic example is SAR hedonic pricing models of residential home values Pace et al. (2004). The value of a house sold has a direct impact on other residential home prices in the area, and has been shown to be a valuable addition to traditional home price models (Anselin and Lozano-Gracia, 2007). Conceptually, the SAR would be the correct model to assess the impacts of different zoning regimes by studying the effect that neighbors' transportation behavior may have on an individual's transportation choices. While theoretically the model has justifiable merit in controlling for spatial dependence, it is important to not that this model does not distinguish the direction of causality. It is quite possible that people who enjoy non-auto forms of transportation tend to live in the same locations because these locations provide employment, leisure, and shopping in close enough proximity to make non-auto trips more convenient. However, this model does identify if there is spatially clustered transportation behavior, and how fast this clustering effect deteriorates with distance and is therefore relevant to the study of spatial effects of zoning laws on transportation mode choice.

1.2.5. The Spatial Error Model. In contrast to the spatial autoregressive model, the spatial error model (SER) allows for heterogeneous effects of independent regressors across space. This adaptation of the traditional OLS model allows for both global coefficients and

local variation across space of coefficients to be modeled. In the binomial choice context, the latent variable approach of unobserved utility of the resulting choice indicator is used for the probit estimator similar to the process described for the SAR model. The SER binomial choice model can be formally stated as:

$$
\begin{aligned}
y_i^* &= X\beta + u \\
u &= \lambda W u + e \\
e &\sim N(0, \sigma^2 I_n) \\
y_i &= 1, \quad \text{if} \quad y_i^* \geq 0 \\
y_i &= 0, \quad \text{if} \quad y_i^* < 0
\end{aligned}
\tag{5}
$$

Where W is the spatial weights matrix. The SER model allows for spatial variance of the error term and the estimation of its spatial lag parameter λ. Unlike the SAR model, indirect, and direct effects cannot be estimated because there is no feedback loop of changes in the independent regressors on the dependent variable, since the there is no autocorrelation parameter present. The parameter λ represents the extent to which heterogeneous independent coefficient estimates vary across space.

1.2.6. Spatial Durbin Model. The spatial Durbin model (SDM) allows for the estimation of both spatial autocorrelation and spatial dependence, simultaneously including a spatially lagged dependent variable as well as spatially lagged independent variables in a single model. The advantages of this model are the simultaneous control of both spatial dependence and spatial heterogeneity, but in practice can suffer from the curse of dimensionality. One advantage of the Bayesian approach to model estimation is the

ability to estimate such models without running into non-convergence problems that exist in maximization procedures employed in maximum likelihood and generalized method of moments estimation that can lead to severe computational challenges. The binomial probit SDM model can be formally stated as:

$$
\begin{aligned}
y_i^* &= \rho W y + X\beta + WX\theta + \varepsilon \\
\varepsilon &\sim N(0, \sigma^2 I_n) \\
y_i &= 1, \quad \text{if} \quad y_i^* \geq 0 \\
y_i &= 0, \quad \text{if} \quad y_i^* < 0
\end{aligned}
\tag{6}
$$

where ρ is the estimated parameter of spatial autocorrelation of the dependent variable,β is the estimated vector of parameters on the independent variables, and θ is the vector of estimated parameters on the spatially lagged independent variables.

The estimation of the SDM is similar to that of the SAR model with the independent variables multiplied by the spatial weights matrix added as additional independent variables. When estimating the SAR, SEM, and SDM models, it is important to note that the true data generating process is unknown, and that the true data generating process and resulting spatial dependence and spatial heterogeneity. LeSage and Pace (2009) detail the advantages of each approach, and determine that when the correct model is unknown and not dictated by theory, only the SDM gives unbiased results even if the true model is SAR or SEM. More particularly, when the true data generating process is the SEM model, SAR and SDM will produce unbiased but inefficient estimates. When the true data generating process is the SAR model, the SEM model produces biased estimates, while

the SDM would not. If the true data generating process was the SDM model, the other models will have omitted variable bias. The SAR, SEM, and SDM versions of the travel behavior - built environment models are estimated below using both a binary and inverse distance weighted row standardized spatial weights matrix. General measures of spatial dependence and model validity are also estimated.

1.2.7. Estimation Techniques. McMillen (1992) was the first to propose techniques for estimating the SAR and SEM probit models. Due to the complicated error structure of the SAR and SEM probit models, direct maximum-likelihood estimation is not possible, however, in the EM procedure, the discrete variable is replaced by the expected value of the underlying latent variable, and the expectation is calculated iteratively until convergence. McMillen (1992) among others deem this procedure impractical for large datasets however. LeSage (2000) outlines several other drawbacks to the procedure. First, the estimation procedure requires the estimation of the likelihood function which prohibits use of the information matrix for calculating the precision of the parameter estimates. Attempts to circumvent this problem produces biased estimation of the covariance matrix. Second, McMillen's approach requires a functional form of the heteroskedastic spatial variance, and leads to varying inferences across alternative specifications. Alternatively, Bayesian estimation techniques do not require these assumptions about the functional form of the error process.

Following the work of Chib (1992) and Albert and Chib (1993) which detail the estimation of probit and logit models for discrete choices using Markov Chain Monte Carlo estimation in a Bayesian context, LeSage (2000) proposes a Bayesian estimation technique based on the Gibbs sampling approach. The estimation technique specifies a complete set of prior distributions for all parameters in the model and then samples from these

distributions until a large number of parameter draws are obtained that converge to the true join posterior distribution of the parameters. This approach overcomes the drawbacks of the approach proposed by McMillen (1992) because the posterior distributions are available to calculate valid inference measures of the parameter estimates, thus escaping the bias inherent in the EM algorithm and the necessity to specify the functional form of model variance over space *apriori*. The likelihood function for the SAR and SEM models is

$$L(y, W|\rho, \beta, \sigma^2) = \frac{1}{2\pi\sigma^{2(n/2)}}|I_n - \rho W|exp\left\{-\frac{1}{2\sigma^2}(\varepsilon'\varepsilon)\right\} \tag{7}$$

where

$\varepsilon = (I_n - \rho W)y - X\beta$ for the SAR model,

$\varepsilon = (I_n - \rho W)(y - X\theta) - X\beta$ for the SDM model, and

$\varepsilon = (I_n - \lambda W)(y - X\beta)$ for the SEM model.(LeSage, 2000, p.23)

1.3. Econometric Model and Results

1.3.1. Econometric Model. Three econometric models are specified following the theoretical specifications for the SAR, SEM, and SDM above. The binary choice indicator variable y is set to 1 if the survey respondent used non-auto transportation for an observed tour, and 0 otherwise. The spatial probit model is for the SAR, SEM, and SDM is comprised of the travel choice indicator variable and the independent regressors which are the same as in the previous chapter. The independent regressor matrix $X = [I\ S\ BE]$ where I is an $n\ x\ 1$ vector of ones, S is a matrix of sociodemographic characteristics, and BE is a

matrix of built environment characteristics including zoning variable used in the previous chapter. The formal equation to be estimated for the SDM is then:

$$
\begin{aligned}
& y_i^* = \rho W y + [I\ S\ BE]\beta + W[I\ S\ BE]\theta + \varepsilon \\
& \varepsilon \sim N(0, \sigma^2 I_n) \\
& y_i = 1, \quad \text{if} \quad y_i^* \geq 0 \\
& y_i = 0, \quad \text{if} \quad y_i^* < 0
\end{aligned}
\tag{8}
$$

where $X = [I\ S\ BE]$ and follows the same substitution for the SAR and SEM.

1.3.2. Determination of the Spatial Weights Matrix. The spatial weight matrix, W, in the equations above is developed by a two step process. In the first step, observations are determined to be spatial neighbors if they are within a distance d from one another. In the second step, the neighbor matrix is transformed into a spatial weight matrix W by either row standardizing the matrix so that all rows sum to 1, or applying a function based on distance or some other criteria to the neighbor matrix. While there are no generally accepted procedures for demeriting the correct weighting structure to use for W, I apply the two most commonly used weighting schemes of row standardization of the neighbor matrix, and a weight that declines with distance where the weight of each neighboring observation is weighted by the inverse of distance $W_{ij} = 1/d_{ij}$, where d is the distance between observations in miles, which is also then row standardized so that each row sums to unity. The bandwidth used to create the neighbor matrix was the minimum distance necessary so that each observation included at least one neighbor, 1.076 miles. While it is possible to estimate spatial models with some observations having no neighbors, in

practice this also causes far more problems than the benefits of having more restrictive definitions of spatial neighbors. I estimate the SAR and SEM models using each spatial weight matrix and compare the results below.

1.3.3. Estimation. The SAR and SEM have been estimated in the past using maximum likelihood techniques, as well as more recently with Bayesian techniques. The estimation of the model using Bayesian techniques has some advantages over maximum likelihood, the most important being the posterior distributions of draws which can be used for inference (LeSage, 2000).

The SAR and SEM models are estimated with a Bayesian model that takes 1,000 draws with a burn-in of 100 draws. Model results are listed in Table 1.3. All estimations are implemented in the software system R (R Core Team, 2014). The spatial weights matrix was constructed and standardized using the R add-on package *spded* (Bivand et al., 2013; Bivand and Gianfranco, 2015).The spatial probit SAR, SEM, and SDM models are estimated using the Bayesian approach implemented in the R package *spatialprobit* (Wilhelm and Godinho de Matos, 2014).

Table 1.3. Travel Behavior-Built Environment Spatial Probit Models

Dependent Variable: Non-auto Transportation Mode = 1				
Variable	SAR	SAR (1/d)	SEM	SEM (1/d)
Intercept	0.31676	0.43406	0.07469	−0.03384
HH size	−0.04959*	−0.06346***	−0.05179*	−0.05318**
HH vehicles	−0.36400***	−0.32243***	−0.36572***	−0.36058***
HH bikes	0.05848***	0.05092***	0.05978***	0.05869***
Male	0.18420***	0.18697***	0.18490***	0.18252***
Age	−0.01314***	−0.01279***	−0.01344***	−0.01343***
Income (000s)	−0.00008	−0.00007	−0.00005	−0.00019
College education	0.04738	0.05583	0.04805	0.04598
Employed	−0.08549	−0.10610**	−0.09089*	−0.08567
Tour distance	−0.01281***	−0.01269***	−0.01318***	−0.01300***
Tour crosses highway	−0.77688***	−0.76015***	−0.80222***	−0.79699***
Miles bike lanes < 1 M.	−0.01424*	−0.00993	−0.01215	−0.00928
Miles of bus routes < 0.5 M.	0.01538***	0.01344***	0.01440***	0.01565***
Bus stops < 0.5 M.	0.00741**	0.00627**	0.01012***	0.00916***
Rail stops < 0.5 M.	−0.09197**	−0.08271**	−0.09444**	−0.09912**
Miles of rail lines < 0.5 M.	0.03478***	0.03222***	0.03792***	0.04019***
Intersections with 0.5 M	−0.00042	−0.00011	−0.00096	−0.00080

CBG population/sq. mile	0.00001**	0.00001**	0.00001*	0.00002**
CBG jobs/sq. mile	0.00000	0.00000	0.00000	0.00000
Work stops	0.04188	0.04296*	0.04650*	0.04432*
Shopping stops	−0.18926***	−0.18820***	−0.18902***	−0.19124***
Social stops	−0.10320**	−0.11363**	−0.11045*	−0.10820**
Residential Low Density, 0-1/4 mile	−0.00986**	−0.00709**	−0.00996**	−0.00980**
Residential Medium Density, 0-1/4 mile	−0.00871**	−0.00638*	−0.00947**	−0.00901**
Residential High Density 0-1/4 mile	−0.01006**	−0.00753**	−0.00999**	−0.01010**
Business Low Density 0-1/4 mile	0.00953	0.00852	0.00977	0.00928
Business High Density 0-1/4 mile	−0.00378	−0.00204	−0.00372	−0.00340
Industrial 0-1/4 mile	−0.00793	−0.00666	−0.00799	−0.00743
Residential Low Density, 1/4-1/2 mile	0.01401**	0.01057*	0.01174	0.01261**
Residential Medium Density, 1/4-1/2 mile	0.01218*	0.00888	0.01038	0.01061
Residential High Density 1/4-1/2 mile	0.01299*	0.00999	0.01121	0.01248*
Business Low Density 1/4-1/2 mile	−0.01542	−0.01453	−0.01616	−0.01534
Business High Density 1/4-1/2 mile	−0.00264	−0.00302	−0.00394	−0.00413
Industrial 1/4-1/2 mile	0.01073	0.00908	0.00931	0.00909
Residential Low Density, 1/2-1 mile	0.00333	0.00259	0.00427	0.00378
Residential Medium Density, 1/2-1 mile	0.00481	0.00354	0.00470	0.00457
Residential High Density 1/2-1 mile	0.00522	0.00469	0.00865	0.00779
Business Low Density 1/2-1 mile	0.02956	0.02772*	0.04160**	0.04013**
Business High Density 1/2-1 mile	0.01247*	0.00901	0.01267*	0.01242*
Industrial 1/2-1 mile	0.00406	0.00231	0.00604	0.00601
Spatial dependece parameter (ρ, λ)	0.27054**	0.33264***	0.38965**	0.14583***

The model results for both the SAR and SEM models using both a row standardized and inverse distance row standardized spatial weights matrix show that there is spatial dependence, with the inverse distance weight matrix spatial parameters ρ and λ significant at the 1 percent level in both the SAR and SEM models, and the row standardized matrix spatial parameters significant at the 5 percent level in both the SAR and SEM models.

The higher coefficient on ρ in the SAR model using inverse distance spatial weighting is likely the result of the of distance decay already being present in the weighting structure, whereas the lower parameter parameter estimate of ρ in the row standardized model indicate a faster decay of spatial dependence, but with all neighbors within approximately one mile of each observation being weighted the same. It may be the case that both models indicate a similar rate of spatial dependence decay. The most notable result of the SAR models is that the coefficients on all three residential zoning density levels are negative and highly significant. This indicates that higher levels of residential zoning of any type decrease the likelihood of using non-auto transportation. Coupled with the

highly significant spatial parameter, this implies that not only will reducing the percentage of residential zoning surrounding a household increase the likelihood of non-auto travel behavior, but that it will also exhibit a feedback loop in surrounding regions, causing more non-auto travel behavior in nearby neighborhoods. The other result that indicates potential for zoning behavior impacts is the significant positive coefficients in the one half to one mile band surrounding respondents' residences. This indicates that increased business within this zoning band increases the likelihood of using auto transportation. Coupled with the findings on the coefficients on the closest band to residential location, this implies that business zoning within one mile but more than a half mile leads to more respondents choosing the auto. This indicates that residential locations surrounded by a band of residential zoning up to one half mile may prefer to drive to shopping, employment, and recreation, and that zoning that precludes much closer businesses my lead to more non-auto travel behavior.

The spatial coefficients in the SEM model are also highly significant, indicating the likelihood of spatial heterogeneity among survey respondents that are spatially close. This indicates that coefficients on explanatory variables are heterogeneous, and that controlling for this dependence in the error structure of the SEM models is warranted. The coefficients on the SEM model have similar values to those found in the SAR model, with similar implications.

While the sign of the coefficients on the explanatory variables indicate the direction of effect on the conditional probability of non-auto transportation behavior, their magnitude cannot be interpreted the same as in OLS or probit models. Due to not non-linearity of the model, and the presence of both spatial dependence and heterogeneity, the impact on a change of one explanatory variable has a spatial feedback loop effect on the dependent

variable due to the presence of the spatially lagged dependent variable in the estimated equation. Therefore, it is necessary to estimate marginal effects of the change in each variable in the model to determine the direct, indirect, and total effects a change in a variable my have. The full list of direct, indirect, and total effects of the change in each independent variable are listed in Appendix A.

While the SAR and SEM models both show significance in some of the zoning variables in determining mode choice, the SDM only shows significance in the low, medium, and high residential zoning types for the binary spatial weights matrix, and no significance in any of the zoning models for the inverse distance weighted spatial weights matrix.

Table 1.4. Travel Behavior-Built Environment Spatial Durbin Models

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	SDM	SDM(1/d)	SDM(1/d)(2)
Intercept	0.98881	0.57300	0.36297
HH size	−0.04751*	0.03555	−0.06827***
HH vehicles	−0.37784***	−0.34637***	−0.32106***
HH bikes	0.06364***	0.02271	0.05129***
Male	0.18636***	0.18974***	0.18499***
Age	−0.01330***	−0.01404***	−0.01321***
Income (000s)	−0.00019	−0.00182**	−0.00013
College education	0.03669	0.03885	0.05136
Employed	−0.07729	−0.07598	−0.10020*
Tour distance	−0.01386***	−0.01325***	−0.01334***
Tour crosses highway	−0.81247***	−0.85403***	−0.77848***
Miles bike lanes < 1 M.	−0.03188	−0.02540	−0.00909
Miles of bus routes < 0.5 M.	0.01100*	0.01048	0.01449***
Bus stops < 0.5 M.	0.01150**	0.00822	0.00636**
Rail stops < 0.5 M.	−0.07510	−0.03997	−0.07039*
Miles of rail lines < 0.5 M.	0.03098	0.05260	0.03507***
Intersections with 0.5 M	0.00007	0.00062	−0.00030
CBG population/sq. mile	0.00000	0.00000	0.00001*
CBG jobs/sq. mile	0.00000	−0.00001*	0.00000
Work stops	0.04785*	0.04115	0.04844*
Shopping stops	−0.19356***	−0.21859***	−0.19162***
Social stops	−0.10037**	−0.12145**	−0.11389**
Residential Low Density, 0-1/4 mile	−0.01097**	−0.00789	−0.00303
Residential Medium Density, 0-1/4 mile	−0.01102**	−0.01261	−0.00818
Residential High Density 0-1/4 mile	−0.00973**	−0.00505	−0.00031
Business Low Density 0-1/4 mile	0.00674	0.00284	0.00694
Business High Density 0-1/4 mile	−0.00581	0.00144	0.00597
Industrial 0-1/4 mile	−0.00914	0.00047	0.00292
Residential Low Density, 1/4-1/2 mile	0.00916	0.00311	−0.00169

Table 1.4. Travel Behavior-Built Environment Spatial Durbin Models

Dependent Variable: Non-auto Transportation Mode = 1 Variable	SDM	SDM(1/d)	SDM(1/d)(2)
Residential Medium Density, 1/4-1/2 mile	0.00897	0.00416	−0.00165
Residential High Density 1/4-1/2 mile	0.00866	−0.00296	−0.00656
Business Low Density 1/4-1/2 mile	−0.01511	0.00981	0.01513
Business High Density 1/4-1/2 mile	−0.00551	−0.00087	−0.00807
Industrial 1/4-1/2 mile	0.00917	−0.00279	−0.00836
Residential Low Density, 1/2-1 mile	−0.00052	−0.01662	−0.01177
Residential Medium Density, 1/2-1 mile	−0.00723	0.01386	0.01483
Residential High Density 1/2-1 mile	0.00272	−0.00186	0.00279
Business Low Density 1/2-1 mile	0.03079	0.11077	0.12770
Business High Density 1/2-1 mile	0.00587	−0.02353	−0.01907
Industrial 1/2-1 mile	−0.00256	−0.02308	−0.01179
(W) HH size	−0.24030	−0.19557***	
(W) HH vehicles	−1.08539***	0.07605	
(W) HH bikes	−0.03585	0.05309	
(W) Male	0.32351	0.02939	
(W) Age	−0.01318	0.00084	
(W) Income (000s)	0.01194	0.00366***	
(W) College education	0.60243	−0.00002	
(W) Employed	0.57433	−0.18813*	
(W) Tour distance	−0.06665	0.00265	
(W) Tour crosses highway	−0.34534	0.37417***	
(W) Miles bike lanes < 1 M.	−0.01824	0.01742	
(W) Miles of bus routes < 0.5 M.	0.02389	−0.00124	
(W) Bus stops < 0.5 M.	−0.00298	−0.00246	
(W) Rail stops < 0.5 M.	0.08848	−0.01816	
(W) Miles of rail lines < 0.5 M.	0.03497	−0.03451	
(W) Intersections with 0.5 M	−0.00499	−0.00163	
(W) CBG population/sq. mile	0.00009**	0.00001	
(W) CBG jobs/sq. mile	−0.00001	0.00001**	
(W) Work stops	0.50715	0.02970	
(W) Shopping stops	−0.67047	0.16946***	
(W) Social stops	0.96534	0.10033	
(W) Residential Low Density, 0-1/4 mile	−0.02058	0.00270	−0.00495
(W) Residential Medium Density, 0-1/4 mile	0.01808	0.01012	0.00366
(W) Residential High Density 0-1/4 mile	0.00115	−0.00063	−0.00967
(W) Business Low Density 0-1/4 mile	0.02323	0.01160	0.01005
(W) Business High Density 0-1/4 mile	0.02246	−0.00304	−0.01003
(W) Industrial 0-1/4 mile	0.04082	−0.01076	−0.01544
(W) Residential Low Density, 1/4-1/2 mile	0.04529	0.00349	0.01245
(W) Residential Medium Density, 1/4-1/2 mile	0.00616	0.00268	0.01276
(W) Residential High Density 1/4-1/2 mile	0.00141	0.01235	0.02050
(W) Business Low Density 1/4-1/2 mile	0.01987	−0.03784	−0.04295
(W) Business High Density 1/4-1/2 mile	−0.06022	−0.01130	−0.00003
(W) Industrial 1/4-1/2 mile	−0.04551	0.01212	0.02171
(W) Residential Low Density, 1/2-1 mile	−0.00610	0.01969	0.01667
(W) Residential Medium Density, 1/2-1 mile	−0.00045	−0.01628	−0.01486
(W) Residential High Density 1/2-1 mile	−0.01249	0.00069	0.00016
(W) Business Low Density 1/2-1 mile	−0.02968	−0.08786	−0.10207
(W) Business High Density 1/2-1 mile	0.07904*	0.03905	0.03703
(W) Industrial 1/2-1 mile	0.04251	0.02980	0.01579
(W) rho	−0.88072***	0.40718***	0.31299***

The log likelihood test of all of the models in this chapter indicate that the Spatial Durban Model using the inverse distance spatial weights matrix is the best fit to the existing data. A summary of the log likelihood of each of the models tested in this chapter are shown in Table 1.5.

Table 1.5. Log Likelihood Tests

Model	Log Likelihood	Degrees of Freedom	AIC	BIC
SAR	−1812.898	41	3707.797	3975.998
SAR(1/d)	−1822.201	41	3726.403	3994.604
SEM	−1816.261	42	3716.521	3991.264
SEM(1/d)	−1815.688	42	3715.377	3990.119
SDM	−1788.188	80	3736.236	4259.556
SDM(1/d)	−1781.000	80	3722.001	4245.320
SDM(1/d)(2)	−1808.953	59	3735.906	4121.855

Theoretically, modeling spatial neighbors as having an impact that declines with distance makes the most intuitive interpretation of the results. However, the lack of significance of the zoning variables in the spatial Durban model with an inverse distance spatial weights matrix calls into question the validity of the zoning variables that are significant in the spatial Durban model using binary weights and the previous SAR and SEM models. It may be the case that the zoning variables are highly correlated with other variables that are a result of zoning restrictions, and therefore the effect of zoning restrictions are subsumed in these other variables that are the result of long standing zoning laws at the local level. Comparing the use of the two spatial weights matrices in each model, the binary row standardized spatial weights matrix leads to a better posterior distribution fit to the data, indicating that the binary matrix is preferred to the inverse distance matrix. This indicates that the spatial effects may be strong within the distance used to specify spatial neighbors, just over one mile.

1.3.4. (Marginal Effects and Elasticitiets). The sample distributions of coefficients in the Bayesian estimation results are used to compute marginal effects of a change in independent variables of the model on the probability of probability of non-auto travel mode choice. In spatial models, a change in an explanatory variable x_i

To calculate the marginal effects, the change of each variable is taken at the mean of the posterior distribution and the mean of the expected probability of the binary dependent variable, which is 16.63%. Marginal effects are reported for the direct, indirect, and total marginal effects of a change in each independent variable. Indirect effects represent the spatially lagged effect on the autocorrelated dependent variable of a change in one of the independent variables. The sum of direct and indirect effects equals the total effect of a change in the independent variables after the feedback loop of the change has run its course. Dummy variable elasticities are not reported.

¡¡¡¡¡¡¡ HEAD

Table 1.6. Marginal Effects: SAR Model, Binary Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Direct	Indirect	Total
HH size	−0.00971	−0.00384	−0.01354
HH vehicles	−0.07138	−0.02836	−0.09975
HH bikes	0.01146	0.00453	0.01599
Male	0.03620	0.01405	0.05025
Age	−0.00258	−0.00102	−0.00360
Income (000s)	−0.00002	−0.00001	−0.00002
College education	0.00920	0.00389	0.01309
Employed	−0.01684	−0.00671	−0.02355
Tour distance	−0.00251	−0.00100	−0.00352
Tour crosses highway	−0.15237	−0.06040	−0.21277
Miles bike lanes < 1 M.	−0.00280	−0.00116	−0.00397
Miles of bus routes < 0.5 M.	0.00302	0.00121	0.00423
Bus stops < 0.5 M.	0.00145	0.00055	0.00200
Rail stops < 0.5 M.	−0.01807	−0.00711	−0.02518
Miles of rail lines < 0.5 M.	0.00680	0.00268	0.00948
Intersections with 0.5 M	−0.00008	−0.00003	−0.00011

CBG population/sq. mile	0.00000	0.00000	0.00000
CBG jobs/sq. mile	0.00000	0.00000	0.00000
Work stops	0.00815	0.00345	0.01160
Shopping stops	−0.03710	−0.01483	−0.05193
Social stops	−0.02035	−0.00788	−0.02823
Residential Low Density, 0-1/4 mile	−0.00194	−0.00076	−0.00270
Residential Medium Density, 0-1/4 mile	−0.00171	−0.00068	−0.00240
Residential High Density 0-1/4 mile	−0.00198	−0.00078	−0.00276
Business Low Density 0-1/4 mile	0.00186	0.00075	0.00261
Business High Density 0-1/4 mile	−0.00075	−0.00030	−0.00105
Industrial 0-1/4 mile	−0.00156	−0.00062	−0.00218
Residential Low Density, 1/4-1/2 mile	0.00275	0.00112	0.00387
Residential Medium Density, 1/4-1/2 mile	0.00239	0.00099	0.00337
Residential High Density 1/4-1/2 mile	0.00255	0.00103	0.00358
Business Low Density 1/4-1/2 mile	−0.00303	−0.00118	−0.00422
Business High Density 1/4-1/2 mile	−0.00051	−0.00018	−0.00069
Industrial 1/4-1/2 mile	0.00211	0.00086	0.00297
Residential Low Density, 1/2-1 mile	0.00065	0.00026	0.00091
Residential Medium Density, 1/2-1 mile	0.00095	0.00039	0.00133
Residential High Density 1/2-1 mile	0.00103	0.00038	0.00141
Business Low Density 1/2-1 mile	0.00577	0.00226	0.00803
Business High Density 1/2-1 mile	0.00245	0.00098	0.00343
Industrial 1/2-1 mile	0.00079	0.00031	0.00110

TABLE 1.7. Elasticities: SAR Model, Binary Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Direct	Indirect	Total
HH size	−0.058	−0.023	−0.081
HH vehicles	−0.429	−0.171	−0.600
HH bikes	0.069	0.027	0.096
Age	−0.015	−0.006	−0.022
Income (000s)	−0.000	−0.000	−0.000
Tour distance	−0.015	−0.006	−0.021
Miles bike lanes < 1 M.	−0.017	−0.007	−0.024
Miles of bus routes < 0.5 M.	0.018	0.007	0.025
Bus stops < 0.5 M.	0.009	0.003	0.012
Rail stops < 0.5 M.	−0.109	−0.043	−0.151
Miles of rail lines < 0.5 M.	0.041	0.016	0.057
Intersections with 0.5 M	−0.001	−0.000	−0.001
CBG population/sq. mile	0.000	0.000	0.000
CBG jobs/sq. mile	0.000	0.000	0.000
Work stops	0.049	0.021	0.070

Shopping stops	−0.223	−0.089	−0.312
Social stops	−0.122	−0.047	−0.170
Residential Low Density, 0-1/4 mile	−0.012	−0.005	−0.016
Residential Medium Density, 0-1/4 mile	−0.010	−0.004	−0.014
Residential High Density 0-1/4 mile	−0.012	−0.005	−0.017
Business Low Density 0-1/4 mile	0.011	0.005	0.016
Business High Density 0-1/4 mile	−0.004	−0.002	−0.006
Industrial 0-1/4 mile	−0.009	−0.004	−0.013
Residential Low Density, 1/4-1/2 mile	0.017	0.007	0.023
Residential Medium Density, 1/4-1/2 mile	0.014	0.006	0.020
Residential High Density 1/4-1/2 mile	0.015	0.006	0.022
Business Low Density 1/4-1/2 mile	−0.018	−0.007	−0.025
Business High Density 1/4-1/2 mile	−0.003	−0.001	−0.004
Industrial 1/4-1/2 mile	0.013	0.005	0.018
Residential Low Density, 1/2-1 mile	0.004	0.002	0.006
Residential Medium Density, 1/2-1 mile	0.006	0.002	0.008
Residential High Density 1/2-1 mile	0.006	0.002	0.008
Business Low Density 1/2-1 mile	0.035	0.014	0.048
Business High Density 1/2-1 mile	0.015	0.006	0.021
Industrial 1/2-1 mile	0.005	0.002	0.007

=======

¿¿¿¿¿¿¿ 45edc35290f086893465e81a71f2ff00bb782ec8

TABLE 1.8. Marginal Effects: SDM Model, Binary Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Direct	Indirect	Total
HH size	−0.00915	0.00432	−0.00483
HH vehicles	−0.07278	0.03433	−0.03845
HH bikes	0.01226	−0.00578	0.00648
Male	0.03591	−0.01696	0.01896
Age	−0.00256	0.00121	−0.00135
Income (000s)	−0.00004	0.00002	−0.00002
College education	0.00702	−0.00330	0.00372
Employed	−0.01490	0.00703	−0.00786
Tour distance	−0.00267	0.00126	−0.00141
Tour crosses highway	−0.15647	0.07385	−0.08263
Miles bike lanes < 1 M.	−0.00614	0.00289	−0.00325
Miles of bus routes < 0.5 M.	0.00212	−0.00100	0.00112
Bus stops < 0.5 M.	0.00222	−0.00105	0.00117
Rail stops < 0.5 M.	−0.01451	0.00687	−0.00764
Miles of rail lines < 0.5 M.	0.00596	−0.00280	0.00316

Intersections with 0.5 M	0.00001	−0.00001	0.00001
CBG population/sq. mile	0.00000	−0.00000	0.00000
CBG jobs/sq. mile	0.00000	−0.00000	0.00000
Work stops	0.00921	−0.00434	0.00486
Shopping stops	−0.03728	0.01758	−0.01970
Social stops	−0.01934	0.00912	−0.01021
Residential Low Density, 0-1/4 mile	−0.00212	0.00100	−0.00112
Residential Medium Density, 0-1/4 mile	−0.00213	0.00100	−0.00112
Residential High Density 0-1/4 mile	−0.00188	0.00089	−0.00099
Business Low Density 0-1/4 mile	0.00129	−0.00061	0.00068
Business High Density 0-1/4 mile	−0.00112	0.00053	−0.00059
Industrial 0-1/4 mile	−0.00177	0.00083	−0.00093
Residential Low Density, 1/4-1/2 mile	0.00177	−0.00084	0.00093
Residential Medium Density, 1/4-1/2 mile	0.00173	−0.00082	0.00091
Residential High Density 1/4-1/2 mile	0.00168	−0.00079	0.00088
Business Low Density 1/4-1/2 mile	−0.00291	0.00137	−0.00154
Business High Density 1/4-1/2 mile	−0.00106	0.00050	−0.00056
Industrial 1/4-1/2 mile	0.00177	−0.00083	0.00093
Residential Low Density, 1/2-1 mile	−0.00010	0.00005	−0.00005
Residential Medium Density, 1/2-1 mile	−0.00140	0.00066	−0.00073
Residential High Density 1/2-1 mile	0.00052	−0.00024	0.00028
Business Low Density 1/2-1 mile	0.00591	−0.00277	0.00314
Business High Density 1/2-1 mile	0.00112	−0.00052	0.00060
Industrial 1/2-1 mile	−0.00049	0.00024	−0.00026
(W) HH size	−0.04610	0.02172	−0.02437
(W) HH vehicles	−0.20894	0.09841	−0.11053
(W) HH bikes	−0.00701	0.00333	−0.00368
(W) Male	0.06158	−0.02913	0.03245
(W) Age	−0.00252	0.00119	−0.00133
(W) Income (000s)	0.00230	−0.00108	0.00122
(W) College education	0.11613	−0.05509	0.06105
(W) Employed	0.11107	−0.05282	0.05825
(W) Tour distance	−0.01285	0.00608	−0.00677
(W) Tour crosses highway	−0.06631	0.03128	−0.03503
(W) Miles bike lanes < 1 M.	−0.00352	0.00167	−0.00186
(W) Miles of bus routes < 0.5 M.	0.00460	−0.00217	0.00244
(W) Bus stops < 0.5 M.	−0.00057	0.00027	−0.00030
(W) Rail stops < 0.5 M.	0.01713	−0.00806	0.00907
(W) Miles of rail lines < 0.5 M.	0.00676	−0.00322	0.00354
(W) Intersections with 0.5 M	−0.00096	0.00045	−0.00051
(W) CBG population/sq. mile	0.00002	−0.00001	0.00001
(W) CBG jobs/sq. mile	−0.00000	0.00000	−0.00000
(W) Work stops	0.09765	−0.04606	0.05158
(W) Shopping stops	−0.12957	0.06142	−0.06814
(W) Social stops	0.18598	−0.08792	0.09806
(W) Residential Low Density, 0-1/4 mile	−0.00396	0.00187	−0.00209

(W) Residential Medium Density, 0-1/4 mile	0.00349	−0.00165	0.00184
(W) Residential High Density 0-1/4 mile	0.00024	−0.00012	0.00012
(W) Business Low Density 0-1/4 mile	0.00447	−0.00214	0.00233
(W) Business High Density 0-1/4 mile	0.00434	−0.00207	0.00227
(W) Industrial 0-1/4 mile	0.00787	−0.00371	0.00416
(W) Residential Low Density, 1/4-1/2 mile	0.00870	−0.00410	0.00460
(W) Residential Medium Density, 1/4-1/2 mile	0.00117	−0.00055	0.00062
(W) Residential High Density 1/4-1/2 mile	0.00023	−0.00010	0.00013
(W) Business Low Density 1/4-1/2 mile	0.00383	−0.00178	0.00205
(W) Business High Density 1/4-1/2 mile	−0.01164	0.00551	−0.00613
(W) Industrial 1/4-1/2 mile	−0.00882	0.00416	−0.00466
(W) Residential Low Density, 1/2-1 mile	−0.00114	0.00053	−0.00061
(W) Residential Medium Density, 1/2-1 mile	−0.00005	0.00002	−0.00003
(W) Residential High Density 1/2-1 mile	−0.00237	0.00111	−0.00126
(W) Business Low Density 1/2-1 mile	−0.00566	0.00265	−0.00301
(W) Business High Density 1/2-1 mile	0.01527	−0.00721	0.00806
(W) Industrial 1/2-1 mile	0.00823	−0.00388	0.00435

TABLE 1.9. Elasticities: SDM Model, Binary Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Direct	Indirect	Total
HH size	−0.055	0.026	−0.029
HH vehicles	−0.438	0.206	−0.231
HH bikes	0.074	−0.035	0.039
Age	−0.015	0.007	−0.008
Income (000s)	−0.000	0.000	−0.000
Tour distance	−0.016	0.008	−0.008
Miles bike lanes < 1 M.	−0.037	0.017	−0.020
Miles of bus routes < 0.5 M.	0.013	−0.006	0.007
Bus stops < 0.5 M.	0.013	−0.006	0.007
Rail stops < 0.5 M.	−0.087	0.041	−0.046
Miles of rail lines < 0.5 M.	0.036	−0.017	0.019
Intersections with 0.5 M	0.000	−0.000	0.000
CBG population/sq. mile	0.000	−0.000	0.000
CBG jobs/sq. mile	0.000	−0.000	0.000
Work stops	0.055	−0.026	0.029
Shopping stops	−0.224	0.106	−0.118
Social stops	−0.116	0.055	−0.061
Residential Low Density, 0-1/4 mile	−0.013	0.006	−0.007
Residential Medium Density, 0-1/4 mile	−0.013	0.006	−0.007
Residential High Density 0-1/4 mile	−0.011	0.005	−0.006
Business Low Density 0-1/4 mile	0.008	−0.004	0.004
Business High Density 0-1/4 mile	−0.007	0.003	−0.004

Industrial 0-1/4 mile	−0.011	0.005	−0.006
Residential Low Density, 1/4-1/2 mile	0.011	−0.005	0.006
Residential Medium Density, 1/4-1/2 mile	0.010	−0.005	0.005
Residential High Density 1/4-1/2 mile	0.010	−0.005	0.005
Business Low Density 1/4-1/2 mile	−0.017	0.008	−0.009
Business High Density 1/4-1/2 mile	−0.006	0.003	−0.003
Industrial 1/4-1/2 mile	0.011	−0.005	0.006
Residential Low Density, 1/2-1 mile	−0.001	0.000	−0.000
Residential Medium Density, 1/2-1 mile	−0.008	0.004	−0.004
Residential High Density 1/2-1 mile	0.003	−0.001	0.002
Business Low Density 1/2-1 mile	0.036	−0.017	0.019
Business High Density 1/2-1 mile	0.007	−0.003	0.004
Industrial 1/2-1 mile	−0.003	0.001	−0.002
(W) HH size	−0.277	0.131	−0.147
(W) HH vehicles	−1.256	0.592	−0.665
(W) HH bikes	−0.042	0.020	−0.022
(W) Age	−0.015	0.007	−0.008
(W) Income (000s)	0.014	−0.006	0.007
(W) Tour distance	−0.077	0.037	−0.041
(W) Miles bike lanes < 1 M.	−0.021	0.010	−0.011
(W) Miles of bus routes < 0.5 M.	0.028	−0.013	0.015
(W) Bus stops < 0.5 M.	−0.003	0.002	−0.002
(W) Rail stops < 0.5 M.	0.103	−0.048	0.055
(W) Miles of rail lines < 0.5 M.	0.041	−0.019	0.021
(W) Intersections with 0.5 M	−0.006	0.003	−0.003
(W) CBG population/sq. mile	0.000	−0.000	0.000
(W) CBG jobs/sq. mile	−0.000	0.000	−0.000
(W) Work stops	0.587	−0.277	0.310
(W) Shopping stops	−0.779	0.369	−0.410
(W) Social stops	1.118	−0.529	0.590
(W) Residential Low Density, 0-1/4 mile	−0.024	0.011	−0.013
(W) Residential Medium Density, 0-1/4 mile	0.021	−0.010	0.011
(W) Residential High Density 0-1/4 mile	0.001	−0.001	0.001
(W) Business Low Density 0-1/4 mile	0.027	−0.013	0.014
(W) Business High Density 0-1/4 mile	0.026	−0.012	0.014
(W) Industrial 0-1/4 mile	0.047	−0.022	0.025
(W) Residential Low Density, 1/4-1/2 mile	0.052	−0.025	0.028
(W) Residential Medium Density, 1/4-1/2 mile	0.007	−0.003	0.004
(W) Residential High Density 1/4-1/2 mile	0.001	−0.001	0.001
(W) Business Low Density 1/4-1/2 mile	0.023	−0.011	0.012
(W) Business High Density 1/4-1/2 mile	−0.070	0.033	−0.037
(W) Industrial 1/4-1/2 mile	−0.053	0.025	−0.028
(W) Residential Low Density, 1/2-1 mile	−0.007	0.003	−0.004
(W) Residential Medium Density, 1/2-1 mile	−0.000	0.000	−0.000
(W) Residential High Density 1/2-1 mile	−0.014	0.007	−0.008
(W) Business Low Density 1/2-1 mile	−0.034	0.016	−0.018

(W) Business High Density 1/2-1 mile	0.092	−0.043	0.048
(W) Industrial 1/2-1 mile	0.050	−0.023	0.026

1.4. Conclusions

The evidence provided by the log likelihood test indicate that the Bayesian models of the impact of zoning on travel mode preference favor the Spatial Durban Model with a inverse distance spatial weights matrix indicated in Table 1.4. While none of the zoning variables which are the primary focus of this study are significant, all other models show at least some significances of the zoning variables of interest in this study. This leads to the conclusion that zoning variables may in fact have a significant influence on travel preference, but that zoning variables may manifest themselves in other built environment variables in the model and therefore warrant further study, as they are determined and implemented by a political process.

APPENDIX A

TABLE A.1. Direct Effects: SAR Model, Binary Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Lower 95%	Posterior Mean	Upper 95%
HH size	−0.0181	−0.0097	−0.0012
HH vehicles	−0.0901	−0.0714	−0.0530
HH bikes	0.0062	0.0115	0.0170
Male	0.0200	0.0362	0.0545
Age	−0.0034	−0.0026	−0.0018
Income (000s)	−0.0002	−0.0000	0.0002
College education	−0.0083	0.0092	0.0254
Employed	−0.0345	−0.0168	−0.0003
Tour distance	−0.0035	−0.0025	−0.0016
Tour crosses highway	−0.1892	−0.1524	−0.1142
Miles bike lanes < 1 M.	−0.0053	−0.0028	−0.0003
Miles of bus routes < 0.5 M.	0.0016	0.0030	0.0046
Bus stops < 0.5 M.	0.0005	0.0015	0.0025
Rail stops < 0.5 M.	−0.0329	−0.0181	−0.0049
Miles of rail lines < 0.5 M.	0.0038	0.0068	0.0100
Intersections with 0.5 M	−0.0004	−0.0001	0.0002
CBG population/sq. mile	0.0000	0.0000	0.0000
CBG jobs/sq. mile	−0.0000	0.0000	0.0000
Work stops	−0.0004	0.0082	0.0164
Shopping stops	−0.0503	−0.0371	−0.0246
Social stops	−0.0382	−0.0204	−0.0039
Residential Low Density, 0-1/4 mile	−0.0033	−0.0019	−0.0006
Residential Medium Density, 0-1/4 mile	−0.0030	−0.0017	−0.0005
Residential High Density 0-1/4 mile	−0.0034	−0.0020	−0.0006
Business Low Density 0-1/4 mile	−0.0006	0.0019	0.0043
Business High Density 0-1/4 mile	−0.0022	−0.0007	0.0006
Industrial 0-1/4 mile	−0.0035	−0.0016	0.0002
Residential Low Density, 1/4-1/2 mile	0.0005	0.0027	0.0051
Residential Medium Density, 1/4-1/2 mile	−0.0000	0.0024	0.0048
Residential High Density 1/4-1/2 mile	0.0003	0.0026	0.0049
Business Low Density 1/4-1/2 mile	−0.0077	−0.0030	0.0017
Business High Density 1/4-1/2 mile	−0.0028	−0.0005	0.0019
Industrial 1/4-1/2 mile	−0.0003	0.0021	0.0048
Residential Low Density, 1/2-1 mile	−0.0013	0.0007	0.0027
Residential Medium Density, 1/2-1 mile	−0.0011	0.0009	0.0031
Residential High Density 1/2-1 mile	−0.0011	0.0010	0.0032

Business Low Density 1/2-1 mile	0.0000	0.0058	0.0123
Business High Density 1/2-1 mile	0.0002	0.0024	0.0048
Industrial 1/2-1 mile	−0.0015	0.0008	0.0030

Table A.2. Indirect Effects: SAR Model, Binary Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Lower 95%	Posterior Mean	Upper 95%
HH size	−0.0096	−0.0038	−0.0001
HH vehicles	−0.0585	−0.0284	−0.0045
HH bikes	0.0006	0.0045	0.0101
Male	0.0021	0.0140	0.0316
Age	−0.0021	−0.0010	−0.0002
Income (000s)	−0.0001	−0.0000	0.0001
College education	−0.0023	0.0039	0.0131
Employed	−0.0190	−0.0067	0.0003
Tour distance	−0.0022	−0.0010	−0.0001
Tour crosses highway	−0.1261	−0.0604	−0.0097
Miles bike lanes < 1 M.	−0.0029	−0.0012	−0.0000
Miles of bus routes < 0.5 M.	0.0002	0.0012	0.0028
Bus stops < 0.5 M.	0.0001	0.0006	0.0012
Rail stops < 0.5 M.	−0.0173	−0.0071	−0.0003
Miles of rail lines < 0.5 M.	0.0004	0.0027	0.0059
Intersections with 0.5 M	−0.0002	−0.0000	0.0001
CBG population/sq. mile	0.0000	0.0000	0.0000
CBG jobs/sq. mile	−0.0000	0.0000	0.0000
Work stops	−0.0002	0.0034	0.0095
Shopping stops	−0.0319	−0.0148	−0.0022
Social stops	−0.0192	−0.0079	−0.0003
Residential Low Density, 0-1/4 mile	−0.0018	−0.0008	−0.0001
Residential Medium Density, 0-1/4 mile	−0.0016	−0.0007	−0.0000
Residential High Density 0-1/4 mile	−0.0019	−0.0008	−0.0001
Business Low Density 0-1/4 mile	−0.0002	0.0008	0.0022
Business High Density 0-1/4 mile	−0.0011	−0.0003	0.0002
Industrial 0-1/4 mile	−0.0018	−0.0006	0.0001
Residential Low Density, 1/4-1/2 mile	0.0000	0.0011	0.0029
Residential Medium Density, 1/4-1/2 mile	−0.0001	0.0010	0.0026
Residential High Density 1/4-1/2 mile	−0.0000	0.0010	0.0028
Business Low Density 1/4-1/2 mile	−0.0037	−0.0012	0.0006
Business High Density 1/4-1/2 mile	−0.0013	−0.0002	0.0007
Industrial 1/4-1/2 mile	−0.0001	0.0009	0.0024
Residential Low Density, 1/2-1 mile	−0.0005	0.0003	0.0012
Residential Medium Density, 1/2-1 mile	−0.0004	0.0004	0.0016
Residential High Density 1/2-1 mile	−0.0005	0.0004	0.0015

Business Low Density 1/2-1 mile	−0.0001	0.0023	0.0062
Business High Density 1/2-1 mile	0.0000	0.0010	0.0027
Industrial 1/2-1 mile	−0.0005	0.0003	0.0014

Table A.3. Total Effects: SAR Model, Binary Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Lower 95%	Posterior Mean	Upper 95%
HH size	−0.0254	−0.0135	−0.0017
HH vehicles	−0.1346	−0.0997	−0.0731
HH bikes	0.0085	0.0160	0.0247
Male	0.0291	0.0502	0.0771
Age	−0.0049	−0.0036	−0.0025
Income (000s)	−0.0003	−0.0000	0.0002
College education	−0.0111	0.0131	0.0371
Employed	−0.0479	−0.0236	−0.0003
Tour distance	−0.0051	−0.0035	−0.0022
Tour crosses highway	−0.2872	−0.2128	−0.1573
Miles bike lanes < 1 M.	−0.0076	−0.0040	−0.0005
Miles of bus routes < 0.5 M.	0.0022	0.0042	0.0068
Bus stops < 0.5 M.	0.0008	0.0020	0.0034
Rail stops < 0.5 M.	−0.0452	−0.0252	−0.0068
Miles of rail lines < 0.5 M.	0.0054	0.0095	0.0142
Intersections with 0.5 M	−0.0005	−0.0001	0.0003
CBG population/sq. mile	0.0000	0.0000	0.0000
CBG jobs/sq. mile	−0.0000	0.0000	0.0000
Work stops	−0.0005	0.0116	0.0244
Shopping stops	−0.0744	−0.0519	−0.0329
Social stops	−0.0516	−0.0282	−0.0051
Residential Low Density, 0-1/4 mile	−0.0048	−0.0027	−0.0008
Residential Medium Density, 0-1/4 mile	−0.0044	−0.0024	−0.0007
Residential High Density 0-1/4 mile	−0.0049	−0.0028	−0.0009
Business Low Density 0-1/4 mile	−0.0008	0.0026	0.0062
Business High Density 0-1/4 mile	−0.0032	−0.0011	0.0009
Industrial 0-1/4 mile	−0.0050	−0.0022	0.0003
Residential Low Density, 1/4-1/2 mile	0.0007	0.0039	0.0074
Residential Medium Density, 1/4-1/2 mile	−0.0000	0.0034	0.0067
Residential High Density 1/4-1/2 mile	0.0004	0.0036	0.0074
Business Low Density 1/4-1/2 mile	−0.0108	−0.0042	0.0022
Business High Density 1/4-1/2 mile	−0.0039	−0.0007	0.0027
Industrial 1/4-1/2 mile	−0.0005	0.0030	0.0068
Residential Low Density, 1/2-1 mile	−0.0018	0.0009	0.0040
Residential Medium Density, 1/2-1 mile	−0.0015	0.0013	0.0045
Residential High Density 1/2-1 mile	−0.0015	0.0014	0.0045

Business Low Density 1/2-1 mile	0.0000	0.0080	0.0168
Business High Density 1/2-1 mile	0.0003	0.0034	0.0069
Industrial 1/2-1 mile	−0.0021	0.0011	0.0042

Table A.4. Direct Effects: SAR Model, Inverse Distance Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Lower 95%	Posterior Mean	Upper 95%
HH size	−0.0198	−0.0123	−0.0046
HH vehicles	−0.0735	−0.0623	−0.0522
HH bikes	0.0055	0.0098	0.0144
Male	0.0203	0.0362	0.0530
Age	−0.0031	−0.0025	−0.0019
Income (000s)	−0.0002	−0.0000	0.0002
College education	−0.0066	0.0108	0.0265
Employed	−0.0374	−0.0206	−0.0042
Tour distance	−0.0032	−0.0025	−0.0017
Tour crosses highway	−0.1662	−0.1469	−0.1275
Miles bike lanes < 1 M.	−0.0041	−0.0019	0.0002
Miles of bus routes < 0.5 M.	0.0014	0.0026	0.0038
Bus stops < 0.5 M.	0.0004	0.0012	0.0021
Rail stops < 0.5 M.	−0.0285	−0.0160	−0.0043
Miles of rail lines < 0.5 M.	0.0036	0.0062	0.0090
Intersections with 0.5 M	−0.0003	−0.0000	0.0002
CBG population/sq. mile	0.0000	0.0000	0.0000
CBG jobs/sq. mile	−0.0000	0.0000	0.0000
Work stops	−0.0002	0.0083	0.0161
Shopping stops	−0.0466	−0.0364	−0.0264
Social stops	−0.0382	−0.0220	−0.0066
Residential Low Density, 0-1/4 mile	−0.0024	−0.0014	−0.0002
Residential Medium Density, 0-1/4 mile	−0.0023	−0.0012	−0.0001
Residential High Density 0-1/4 mile	−0.0026	−0.0015	−0.0004
Business Low Density 0-1/4 mile	−0.0005	0.0016	0.0038
Business High Density 0-1/4 mile	−0.0016	−0.0004	0.0008
Industrial 0-1/4 mile	−0.0029	−0.0013	0.0003
Residential Low Density, 1/4-1/2 mile	0.0002	0.0020	0.0039
Residential Medium Density, 1/4-1/2 mile	−0.0004	0.0017	0.0036
Residential High Density 1/4-1/2 mile	−0.0001	0.0019	0.0040
Business Low Density 1/4-1/2 mile	−0.0067	−0.0028	0.0012
Business High Density 1/4-1/2 mile	−0.0026	−0.0006	0.0015
Industrial 1/4-1/2 mile	−0.0004	0.0018	0.0040
Residential Low Density, 1/2-1 mile	−0.0012	0.0005	0.0023
Residential Medium Density, 1/2-1 mile	−0.0012	0.0007	0.0026
Residential High Density 1/2-1 mile	−0.0010	0.0009	0.0029

Business Low Density 1/2-1 mile	0.0002	0.0054	0.0109
Business High Density 1/2-1 mile	−0.0002	0.0017	0.0037
Industrial 1/2-1 mile	−0.0016	0.0004	0.0024

TABLE A.5. Indirect Effects: SAR Model, Inverse Distance Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Lower 95%	Posterior Mean	Upper 95%
HH size	−0.0103	−0.0058	−0.0020
HH vehicles	−0.0401	−0.0296	−0.0209
HH bikes	0.0024	0.0047	0.0073
Male	0.0094	0.0171	0.0267
Age	−0.0016	−0.0012	−0.0008
Income (000s)	−0.0001	−0.0000	0.0001
College education	−0.0027	0.0052	0.0129
Employed	−0.0188	−0.0098	−0.0018
Tour distance	−0.0017	−0.0012	−0.0007
Tour crosses highway	−0.0946	−0.0699	−0.0489
Miles bike lanes < 1 M.	−0.0021	−0.0009	0.0001
Miles of bus routes < 0.5 M.	0.0006	0.0012	0.0020
Bus stops < 0.5 M.	0.0002	0.0006	0.0010
Rail stops < 0.5 M.	−0.0139	−0.0076	−0.0019
Miles of rail lines < 0.5 M.	0.0016	0.0030	0.0047
Intersections with 0.5 M	−0.0001	−0.0000	0.0001
CBG population/sq. mile	0.0000	0.0000	0.0000
CBG jobs/sq. mile	−0.0000	0.0000	0.0000
Work stops	−0.0001	0.0040	0.0085
Shopping stops	−0.0250	−0.0173	−0.0108
Social stops	−0.0187	−0.0105	−0.0027
Residential Low Density, 0-1/4 mile	−0.0013	−0.0006	−0.0001
Residential Medium Density, 0-1/4 mile	−0.0012	−0.0006	−0.0001
Residential High Density 0-1/4 mile	−0.0013	−0.0007	−0.0002
Business Low Density 0-1/4 mile	−0.0002	0.0008	0.0019
Business High Density 0-1/4 mile	−0.0008	−0.0002	0.0004
Industrial 0-1/4 mile	−0.0014	−0.0006	0.0001
Residential Low Density, 1/4-1/2 mile	0.0001	0.0010	0.0020
Residential Medium Density, 1/4-1/2 mile	−0.0002	0.0008	0.0018
Residential High Density 1/4-1/2 mile	−0.0000	0.0009	0.0020
Business Low Density 1/4-1/2 mile	−0.0033	−0.0013	0.0006
Business High Density 1/4-1/2 mile	−0.0013	−0.0003	0.0007
Industrial 1/4-1/2 mile	−0.0002	0.0008	0.0020
Residential Low Density, 1/2-1 mile	−0.0006	0.0002	0.0012
Residential Medium Density, 1/2-1 mile	−0.0006	0.0003	0.0013
Residential High Density 1/2-1 mile	−0.0005	0.0004	0.0014

Business Low Density 1/2-1 mile	0.0001	0.0026	0.0055
Business High Density 1/2-1 mile	−0.0001	0.0008	0.0018
Industrial 1/2-1 mile	−0.0008	0.0002	0.0012

Table A.6. Total Effects: SAR Model, Inverse Distance Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Lower 95%	Posterior Mean	Upper 95%
HH size	−0.0294	−0.0181	−0.0069
HH vehicles	−0.1083	−0.0919	−0.0767
HH bikes	0.0081	0.0145	0.0210
Male	0.0306	0.0533	0.0776
Age	−0.0046	−0.0036	−0.0028
Income (000s)	−0.0003	−0.0000	0.0002
College education	−0.0093	0.0159	0.0388
Employed	−0.0547	−0.0303	−0.0061
Tour distance	−0.0048	−0.0036	−0.0025
Tour crosses highway	−0.2488	−0.2169	−0.1859
Miles bike lanes < 1 M.	−0.0061	−0.0028	0.0003
Miles of bus routes < 0.5 M.	0.0021	0.0038	0.0057
Bus stops < 0.5 M.	0.0005	0.0018	0.0031
Rail stops < 0.5 M.	−0.0413	−0.0236	−0.0061
Miles of rail lines < 0.5 M.	0.0054	0.0092	0.0132
Intersections with 0.5 M	−0.0004	−0.0000	0.0004
CBG population/sq. mile	0.0000	0.0000	0.0000
CBG jobs/sq. mile	−0.0000	0.0000	0.0000
Work stops	−0.0003	0.0123	0.0243
Shopping stops	−0.0689	−0.0537	−0.0386
Social stops	−0.0556	−0.0325	−0.0095
Residential Low Density, 0-1/4 mile	−0.0036	−0.0020	−0.0004
Residential Medium Density, 0-1/4 mile	−0.0034	−0.0018	−0.0002
Residential High Density 0-1/4 mile	−0.0038	−0.0021	−0.0005
Business Low Density 0-1/4 mile	−0.0007	0.0024	0.0057
Business High Density 0-1/4 mile	−0.0023	−0.0006	0.0012
Industrial 0-1/4 mile	−0.0043	−0.0019	0.0004
Residential Low Density, 1/4-1/2 mile	0.0003	0.0030	0.0057
Residential Medium Density, 1/4-1/2 mile	−0.0006	0.0025	0.0054
Residential High Density 1/4-1/2 mile	−0.0001	0.0029	0.0059
Business Low Density 1/4-1/2 mile	−0.0099	−0.0041	0.0020
Business High Density 1/4-1/2 mile	−0.0038	−0.0009	0.0021
Industrial 1/4-1/2 mile	−0.0006	0.0026	0.0059
Residential Low Density, 1/2-1 mile	−0.0018	0.0007	0.0034
Residential Medium Density, 1/2-1 mile	−0.0019	0.0010	0.0038
Residential High Density 1/2-1 mile	−0.0014	0.0013	0.0042

Business Low Density 1/2-1 mile	0.0003	0.0079	0.0159
Business High Density 1/2-1 mile	−0.0003	0.0026	0.0054
Industrial 1/2-1 mile	−0.0023	0.0007	0.0036

Table A.7. Direct Effects: SDM Model, Binary Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Lower 95%	Posterior Mean	Upper 95%
HH size	−0.0175	−0.0091	−0.0006
HH vehicles	−0.0862	−0.0728	−0.0602
HH bikes	0.0071	0.0123	0.0176
Male	0.0198	0.0359	0.0527
Age	−0.0032	−0.0026	−0.0019
Income (000s)	−0.0002	−0.0000	0.0001
College education	−0.0112	0.0070	0.0231
Employed	−0.0327	−0.0149	0.0023
Tour distance	−0.0036	−0.0027	−0.0018
Tour crosses highway	−0.1795	−0.1565	−0.1333
Miles bike lanes < 1 M.	−0.0126	−0.0061	0.0001
Miles of bus routes < 0.5 M.	0.0003	0.0021	0.0040
Bus stops < 0.5 M.	0.0008	0.0022	0.0036
Rail stops < 0.5 M.	−0.0310	−0.0145	0.0020
Miles of rail lines < 0.5 M.	−0.0018	0.0060	0.0145
Intersections with 0.5 M	−0.0004	0.0000	0.0005
CBG population/sq. mile	−0.0000	0.0000	0.0000
CBG jobs/sq. mile	−0.0000	0.0000	0.0000
Work stops	0.0005	0.0092	0.0175
Shopping stops	−0.0474	−0.0373	−0.0276
Social stops	−0.0362	−0.0193	−0.0032
Residential Low Density, 0-1/4 mile	−0.0035	−0.0021	−0.0008
Residential Medium Density, 0-1/4 mile	−0.0037	−0.0021	−0.0007
Residential High Density 0-1/4 mile	−0.0034	−0.0019	−0.0004
Business Low Density 0-1/4 mile	−0.0018	0.0013	0.0043
Business High Density 0-1/4 mile	−0.0027	−0.0011	0.0003
Industrial 0-1/4 mile	−0.0040	−0.0018	0.0003
Residential Low Density, 1/4-1/2 mile	−0.0007	0.0018	0.0043
Residential Medium Density, 1/4-1/2 mile	−0.0011	0.0017	0.0045
Residential High Density 1/4-1/2 mile	−0.0011	0.0017	0.0044
Business Low Density 1/4-1/2 mile	−0.0086	−0.0029	0.0028
Business High Density 1/4-1/2 mile	−0.0038	−0.0011	0.0015
Industrial 1/4-1/2 mile	−0.0015	0.0018	0.0050
Residential Low Density, 1/2-1 mile	−0.0039	−0.0001	0.0045
Residential Medium Density, 1/2-1 mile	−0.0056	−0.0014	0.0034
Residential High Density 1/2-1 mile	−0.0043	0.0005	0.0054

Business Low Density 1/2-1 mile	−0.0061	0.0059	0.0182
Business High Density 1/2-1 mile	−0.0036	0.0011	0.0062
Industrial 1/2-1 mile	−0.0045	−0.0005	0.0041
(W) HH size	−0.1500	−0.0461	0.0524
(W) HH vehicles	−0.3331	−0.2089	−0.0977
(W) HH bikes	−0.0662	−0.0070	0.0506
(W) Male	−0.2548	0.0616	0.3758
(W) Age	−0.0105	−0.0025	0.0056
(W) Income (000s)	−0.0000	0.0023	0.0046
(W) College education	−0.1302	0.1161	0.3765
(W) Employed	−0.1539	0.1111	0.4041
(W) Tour distance	−0.0255	−0.0129	0.0004
(W) Tour crosses highway	−0.2803	−0.0663	0.1321
(W) Miles bike lanes < 1 M.	−0.0157	−0.0035	0.0081
(W) Miles of bus routes < 0.5 M.	−0.0045	0.0046	0.0142
(W) Bus stops < 0.5 M.	−0.0050	−0.0006	0.0040
(W) Rail stops < 0.5 M.	−0.0470	0.0171	0.0778
(W) Miles of rail lines < 0.5 M.	−0.0085	0.0068	0.0211
(W) Intersections with 0.5 M	−0.0022	−0.0010	0.0004
(W) CBG population/sq. mile	0.0000	0.0000	0.0000
(W) CBG jobs/sq. mile	−0.0000	−0.0000	0.0000
(W) Work stops	−0.0506	0.0976	0.2434
(W) Shopping stops	−0.2774	−0.1296	0.0188
(W) Social stops	−0.0798	0.1860	0.4524
(W) Residential Low Density, 0-1/4 mile	−0.0142	−0.0040	0.0058
(W) Residential Medium Density, 0-1/4 mile	−0.0069	0.0035	0.0141
(W) Residential High Density 0-1/4 mile	−0.0106	0.0002	0.0103
(W) Business Low Density 0-1/4 mile	−0.0205	0.0045	0.0314
(W) Business High Density 0-1/4 mile	−0.0076	0.0043	0.0162
(W) Industrial 0-1/4 mile	−0.0071	0.0079	0.0235
(W) Residential Low Density, 1/4-1/2 mile	−0.0048	0.0087	0.0237
(W) Residential Medium Density, 1/4-1/2 mile	−0.0142	0.0012	0.0188
(W) Residential High Density 1/4-1/2 mile	−0.0158	0.0002	0.0174
(W) Business Low Density 1/4-1/2 mile	−0.0366	0.0038	0.0431
(W) Business High Density 1/4-1/2 mile	−0.0278	−0.0116	0.0039
(W) Industrial 1/4-1/2 mile	−0.0294	−0.0088	0.0120
(W) Residential Low Density, 1/2-1 mile	−0.0110	−0.0011	0.0097
(W) Residential Medium Density, 1/2-1 mile	−0.0110	−0.0001	0.0107
(W) Residential High Density 1/2-1 mile	−0.0137	−0.0024	0.0090
(W) Business Low Density 1/2-1 mile	−0.0373	−0.0057	0.0273
(W) Business High Density 1/2-1 mile	0.0023	0.0153	0.0285
(W) Industrial 1/2-1 mile	−0.0058	0.0082	0.0225

TABLE A.8. Indirect Effects: SDM Model, Binary Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Lower 95%	Posterior Mean	Upper 95%
HH size	0.0002	0.0043	0.0084
HH vehicles	0.0256	0.0343	0.0421
HH bikes	−0.0084	−0.0058	−0.0032
Male	−0.0257	−0.0170	−0.0088
Age	0.0009	0.0012	0.0016
Income (000s)	−0.0001	0.0000	0.0001
College education	−0.0111	−0.0033	0.0052
Employed	−0.0011	0.0070	0.0157
Tour distance	0.0008	0.0013	0.0018
Tour crosses highway	0.0556	0.0738	0.0879
Miles bike lanes < 1 M.	−0.0001	0.0029	0.0058
Miles of bus routes < 0.5 M.	−0.0019	−0.0010	−0.0001
Bus stops < 0.5 M.	−0.0018	−0.0010	−0.0004
Rail stops < 0.5 M.	−0.0009	0.0069	0.0153
Miles of rail lines < 0.5 M.	−0.0069	−0.0028	0.0009
Intersections with 0.5 M	−0.0002	−0.0000	0.0002
CBG population/sq. mile	−0.0000	−0.0000	0.0000
CBG jobs/sq. mile	−0.0000	−0.0000	0.0000
Work stops	−0.0085	−0.0043	−0.0002
Shopping stops	0.0121	0.0176	0.0230
Social stops	0.0016	0.0091	0.0174
Residential Low Density, 0-1/4 mile	0.0004	0.0010	0.0017
Residential Medium Density, 0-1/4 mile	0.0003	0.0010	0.0018
Residential High Density 0-1/4 mile	0.0002	0.0009	0.0016
Business Low Density 0-1/4 mile	−0.0021	−0.0006	0.0008
Business High Density 0-1/4 mile	−0.0002	0.0005	0.0013
Industrial 0-1/4 mile	−0.0001	0.0008	0.0019
Residential Low Density, 1/4-1/2 mile	−0.0021	−0.0008	0.0003
Residential Medium Density, 1/4-1/2 mile	−0.0022	−0.0008	0.0005
Residential High Density 1/4-1/2 mile	−0.0021	−0.0008	0.0005
Business Low Density 1/4-1/2 mile	−0.0013	0.0014	0.0041
Business High Density 1/4-1/2 mile	−0.0007	0.0005	0.0018
Industrial 1/4-1/2 mile	−0.0024	−0.0008	0.0007
Residential Low Density, 1/2-1 mile	−0.0021	0.0001	0.0019
Residential Medium Density, 1/2-1 mile	−0.0015	0.0007	0.0027
Residential High Density 1/2-1 mile	−0.0025	−0.0002	0.0020
Business Low Density 1/2-1 mile	−0.0086	−0.0028	0.0029
Business High Density 1/2-1 mile	−0.0029	−0.0005	0.0017
Industrial 1/2-1 mile	−0.0019	0.0002	0.0021
(W) HH size	−0.0245	0.0217	0.0709
(W) HH vehicles	0.0460	0.0984	0.1590
(W) HH bikes	−0.0240	0.0033	0.0319

(W) Male	−0.1835	−0.0291	0.1141
(W) Age	−0.0027	0.0012	0.0050
(W) Income (000s)	−0.0022	−0.0011	0.0000
(W) College education	−0.1791	−0.0551	0.0602
(W) Employed	−0.1893	−0.0528	0.0715
(W) Tour distance	−0.0002	0.0061	0.0122
(W) Tour crosses highway	−0.0637	0.0313	0.1357
(W) Miles bike lanes < 1 M.	−0.0036	0.0017	0.0076
(W) Miles of bus routes < 0.5 M.	−0.0068	−0.0022	0.0021
(W) Bus stops < 0.5 M.	−0.0019	0.0003	0.0023
(W) Rail stops < 0.5 M.	−0.0366	−0.0081	0.0223
(W) Miles of rail lines < 0.5 M.	−0.0102	−0.0032	0.0039
(W) Intersections with 0.5 M	−0.0002	0.0005	0.0011
(W) CBG population/sq. mile	−0.0000	−0.0000	−0.0000
(W) CBG jobs/sq. mile	−0.0000	0.0000	0.0000
(W) Work stops	−0.1165	−0.0461	0.0237
(W) Shopping stops	−0.0086	0.0614	0.1342
(W) Social stops	−0.2186	−0.0879	0.0357
(W) Residential Low Density, 0-1/4 mile	−0.0028	0.0019	0.0068
(W) Residential Medium Density, 0-1/4 mile	−0.0067	−0.0016	0.0033
(W) Residential High Density 0-1/4 mile	−0.0050	−0.0001	0.0050
(W) Business Low Density 0-1/4 mile	−0.0149	−0.0021	0.0095
(W) Business High Density 0-1/4 mile	−0.0079	−0.0021	0.0035
(W) Industrial 0-1/4 mile	−0.0111	−0.0037	0.0034
(W) Residential Low Density, 1/4-1/2 mile	−0.0113	−0.0041	0.0023
(W) Residential Medium Density, 1/4-1/2 mile	−0.0086	−0.0005	0.0067
(W) Residential High Density 1/4-1/2 mile	−0.0082	−0.0001	0.0075
(W) Business Low Density 1/4-1/2 mile	−0.0200	−0.0018	0.0174
(W) Business High Density 1/4-1/2 mile	−0.0018	0.0055	0.0134
(W) Industrial 1/4-1/2 mile	−0.0056	0.0042	0.0136
(W) Residential Low Density, 1/2-1 mile	−0.0045	0.0005	0.0053
(W) Residential Medium Density, 1/2-1 mile	−0.0051	0.0000	0.0052
(W) Residential High Density 1/2-1 mile	−0.0042	0.0011	0.0066
(W) Business Low Density 1/2-1 mile	−0.0132	0.0026	0.0180
(W) Business High Density 1/2-1 mile	−0.0136	−0.0072	−0.0011
(W) Industrial 1/2-1 mile	−0.0107	−0.0039	0.0028

TABLE A.9. Total Effects: SDM Model, Binary Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Lower 95%	Posterior Mean	Upper 95%
HH size	−0.0092	−0.0048	−0.0003
HH vehicles	−0.0454	−0.0384	−0.0325
HH bikes	0.0038	0.0065	0.0092

Male	0.0104	0.0190	0.0277
Age	−0.0017	−0.0014	−0.0010
Income (000s)	−0.0001	−0.0000	0.0001
College education	−0.0059	0.0037	0.0121
Employed	−0.0172	−0.0079	0.0012
Tour distance	−0.0019	−0.0014	−0.0010
Tour crosses highway	−0.0938	−0.0826	−0.0732
Miles bike lanes < 1 M.	−0.0067	−0.0032	0.0001
Miles of bus routes < 0.5 M.	0.0001	0.0011	0.0021
Bus stops < 0.5 M.	0.0004	0.0012	0.0019
Rail stops < 0.5 M.	−0.0161	−0.0076	0.0010
Miles of rail lines < 0.5 M.	−0.0009	0.0032	0.0077
Intersections with 0.5 M	−0.0002	0.0000	0.0003
CBG population/sq. mile	−0.0000	0.0000	0.0000
CBG jobs/sq. mile	−0.0000	0.0000	0.0000
Work stops	0.0002	0.0049	0.0091
Shopping stops	−0.0250	−0.0197	−0.0147
Social stops	−0.0188	−0.0102	−0.0018
Residential Low Density, 0-1/4 mile	−0.0019	−0.0011	−0.0004
Residential Medium Density, 0-1/4 mile	−0.0019	−0.0011	−0.0004
Residential High Density 0-1/4 mile	−0.0017	−0.0010	−0.0002
Business Low Density 0-1/4 mile	−0.0009	0.0007	0.0023
Business High Density 0-1/4 mile	−0.0014	−0.0006	0.0002
Industrial 0-1/4 mile	−0.0021	−0.0009	0.0001
Residential Low Density, 1/4-1/2 mile	−0.0004	0.0009	0.0022
Residential Medium Density, 1/4-1/2 mile	−0.0006	0.0009	0.0024
Residential High Density 1/4-1/2 mile	−0.0006	0.0009	0.0023
Business Low Density 1/4-1/2 mile	−0.0046	−0.0015	0.0015
Business High Density 1/4-1/2 mile	−0.0020	−0.0006	0.0008
Industrial 1/4-1/2 mile	−0.0008	0.0009	0.0026
Residential Low Density, 1/2-1 mile	−0.0021	−0.0001	0.0024
Residential Medium Density, 1/2-1 mile	−0.0029	−0.0007	0.0018
Residential High Density 1/2-1 mile	−0.0022	0.0003	0.0028
Business Low Density 1/2-1 mile	−0.0034	0.0031	0.0096
Business High Density 1/2-1 mile	−0.0019	0.0006	0.0033
Industrial 1/2-1 mile	−0.0023	−0.0003	0.0022
(W) HH size	−0.0786	−0.0244	0.0278
(W) HH vehicles	−0.1746	−0.1105	−0.0513
(W) HH bikes	−0.0343	−0.0037	0.0264
(W) Male	−0.1374	0.0324	0.1938
(W) Age	−0.0055	−0.0013	0.0030
(W) Income (000s)	−0.0000	0.0012	0.0025
(W) College education	−0.0727	0.0610	0.1978
(W) Employed	−0.0796	0.0583	0.2097
(W) Tour distance	−0.0134	−0.0068	0.0002
(W) Tour crosses highway	−0.1486	−0.0350	0.0709

(W) Miles bike lanes < 1 M.	−0.0084	−0.0019	0.0042
(W) Miles of bus routes < 0.5 M.	−0.0025	0.0024	0.0077
(W) Bus stops < 0.5 M.	−0.0027	−0.0003	0.0021
(W) Rail stops < 0.5 M.	−0.0244	0.0091	0.0411
(W) Miles of rail lines < 0.5 M.	−0.0046	0.0035	0.0112
(W) Intersections with 0.5 M	−0.0012	−0.0005	0.0002
(W) CBG population/sq. mile	0.0000	0.0000	0.0000
(W) CBG jobs/sq. mile	−0.0000	−0.0000	0.0000
(W) Work stops	−0.0269	0.0516	0.1303
(W) Shopping stops	−0.1450	−0.0681	0.0096
(W) Social stops	−0.0427	0.0981	0.2383
(W) Residential Low Density, 0-1/4 mile	−0.0075	−0.0021	0.0030
(W) Residential Medium Density, 0-1/4 mile	−0.0037	0.0018	0.0074
(W) Residential High Density 0-1/4 mile	−0.0056	0.0001	0.0055
(W) Business Low Density 0-1/4 mile	−0.0107	0.0023	0.0167
(W) Business High Density 0-1/4 mile	−0.0040	0.0023	0.0085
(W) Industrial 0-1/4 mile	−0.0039	0.0042	0.0122
(W) Residential Low Density, 1/4-1/2 mile	−0.0027	0.0046	0.0123
(W) Residential Medium Density, 1/4-1/2 mile	−0.0074	0.0006	0.0100
(W) Residential High Density 1/4-1/2 mile	−0.0084	0.0001	0.0094
(W) Business Low Density 1/4-1/2 mile	−0.0194	0.0020	0.0239
(W) Business High Density 1/4-1/2 mile	−0.0146	−0.0061	0.0022
(W) Industrial 1/4-1/2 mile	−0.0157	−0.0047	0.0062
(W) Residential Low Density, 1/2-1 mile	−0.0059	−0.0006	0.0050
(W) Residential Medium Density, 1/2-1 mile	−0.0058	−0.0000	0.0056
(W) Residential High Density 1/2-1 mile	−0.0072	−0.0013	0.0047
(W) Business Low Density 1/2-1 mile	−0.0197	−0.0030	0.0140
(W) Business High Density 1/2-1 mile	0.0012	0.0081	0.0150
(W) Industrial 1/2-1 mile	−0.0031	0.0044	0.0117

TABLE A.10. Direct Effects: SDM Model, Inverse Distance Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Lower 95%	Posterior Mean	Upper 95%
HH size	−0.0049	0.0067	0.0184
HH vehicles	−0.0798	−0.0650	−0.0511
HH bikes	−0.0038	0.0043	0.0119
Male	0.0194	0.0356	0.0533
Age	−0.0033	−0.0026	−0.0020
Income (000s)	−0.0006	−0.0003	−0.0001
College education	−0.0105	0.0073	0.0246
Employed	−0.0336	−0.0142	0.0031
Tour distance	−0.0034	−0.0025	−0.0017
Tour crosses highway	−0.1817	−0.1602	−0.1378

Miles bike lanes < 1 M.	−0.0163	−0.0048	0.0073
Miles of bus routes < 0.5 M.	−0.0023	0.0020	0.0062
Bus stops < 0.5 M.	−0.0014	0.0015	0.0044
Rail stops < 0.5 M.	−0.0444	−0.0076	0.0274
Miles of rail lines < 0.5 M.	−0.0052	0.0099	0.0252
Intersections with 0.5 M	−0.0010	0.0001	0.0013
CBG population/sq. mile	−0.0000	0.0000	0.0000
CBG jobs/sq. mile	−0.0000	−0.0000	−0.0000
Work stops	−0.0009	0.0077	0.0160
Shopping stops	−0.0511	−0.0410	−0.0308
Social stops	−0.0398	−0.0228	−0.0062
Residential Low Density, 0-1/4 mile	−0.0054	−0.0015	0.0023
Residential Medium Density, 0-1/4 mile	−0.0064	−0.0024	0.0018
Residential High Density 0-1/4 mile	−0.0048	−0.0009	0.0030
Business Low Density 0-1/4 mile	−0.0061	0.0005	0.0076
Business High Density 0-1/4 mile	−0.0037	0.0003	0.0042
Industrial 0-1/4 mile	−0.0050	0.0001	0.0054
Residential Low Density, 1/4-1/2 mile	−0.0050	0.0006	0.0063
Residential Medium Density, 1/4-1/2 mile	−0.0054	0.0008	0.0069
Residential High Density 1/4-1/2 mile	−0.0067	−0.0006	0.0055
Business Low Density 1/4-1/2 mile	−0.0112	0.0018	0.0151
Business High Density 1/4-1/2 mile	−0.0067	−0.0002	0.0064
Industrial 1/4-1/2 mile	−0.0076	−0.0005	0.0070
Residential Low Density, 1/2-1 mile	−0.0110	−0.0031	0.0053
Residential Medium Density, 1/2-1 mile	−0.0061	0.0026	0.0116
Residential High Density 1/2-1 mile	−0.0094	−0.0004	0.0086
Business Low Density 1/2-1 mile	−0.0038	0.0207	0.0459
Business High Density 1/2-1 mile	−0.0147	−0.0044	0.0054
Industrial 1/2-1 mile	−0.0136	−0.0043	0.0051
(W) HH size	−0.0549	−0.0367	−0.0179
(W) HH vehicles	−0.0072	0.0143	0.0370
(W) HH bikes	−0.0022	0.0100	0.0225
(W) Male	−0.0302	0.0055	0.0384
(W) Age	−0.0010	0.0002	0.0013
(W) Income (000s)	0.0003	0.0007	0.0011
(W) College education	−0.0317	−0.0000	0.0351
(W) Employed	−0.0693	−0.0352	0.0033
(W) Tour distance	−0.0011	0.0005	0.0021
(W) Tour crosses highway	0.0342	0.0703	0.1074
(W) Miles bike lanes < 1 M.	−0.0103	0.0033	0.0162
(W) Miles of bus routes < 0.5 M.	−0.0055	−0.0002	0.0052
(W) Bus stops < 0.5 M.	−0.0040	−0.0005	0.0031
(W) Rail stops < 0.5 M.	−0.0497	−0.0033	0.0423
(W) Miles of rail lines < 0.5 M.	−0.0235	−0.0065	0.0100
(W) Intersections with 0.5 M	−0.0016	−0.0003	0.0010
(W) CBG population/sq. mile	−0.0000	0.0000	0.0000

(W) CBG jobs/sq. mile	0.0000	0.0000	0.0000
(W) Work stops	−0.0111	0.0056	0.0213
(W) Shopping stops	0.0127	0.0318	0.0512
(W) Social stops	−0.0210	0.0189	0.0555
(W) Residential Low Density, 0-1/4 mile	−0.0043	0.0005	0.0053
(W) Residential Medium Density, 0-1/4 mile	−0.0034	0.0019	0.0070
(W) Residential High Density 0-1/4 mile	−0.0055	−0.0001	0.0050
(W) Business Low Density 0-1/4 mile	−0.0076	0.0022	0.0112
(W) Business High Density 0-1/4 mile	−0.0057	−0.0006	0.0046
(W) Industrial 0-1/4 mile	−0.0090	−0.0020	0.0049
(W) Residential Low Density, 1/4-1/2 mile	−0.0066	0.0007	0.0076
(W) Residential Medium Density, 1/4-1/2 mile	−0.0068	0.0005	0.0079
(W) Residential High Density 1/4-1/2 mile	−0.0053	0.0023	0.0101
(W) Business Low Density 1/4-1/2 mile	−0.0240	−0.0071	0.0101
(W) Business High Density 1/4-1/2 mile	−0.0107	−0.0021	0.0058
(W) Industrial 1/4-1/2 mile	−0.0076	0.0023	0.0114
(W) Residential Low Density, 1/2-1 mile	−0.0055	0.0037	0.0129
(W) Residential Medium Density, 1/2-1 mile	−0.0128	−0.0030	0.0062
(W) Residential High Density 1/2-1 mile	−0.0094	0.0001	0.0095
(W) Business Low Density 1/2-1 mile	−0.0449	−0.0164	0.0116
(W) Business High Density 1/2-1 mile	−0.0036	0.0073	0.0189
(W) Industrial 1/2-1 mile	−0.0047	0.0056	0.0161

TABLE A.11. Indirect Effects: SDM Model, Inverse Distance Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Lower 95%	Posterior Mean	Upper 95%
HH size	−0.0031	0.0043	0.0123
HH vehicles	−0.0585	−0.0417	−0.0276
HH bikes	−0.0024	0.0027	0.0080
Male	0.0112	0.0227	0.0349
Age	−0.0023	−0.0017	−0.0011
Income (000s)	−0.0004	−0.0002	−0.0001
College education	−0.0065	0.0046	0.0157
Employed	−0.0222	−0.0092	0.0020
Tour distance	−0.0023	−0.0016	−0.0010
Tour crosses highway	−0.1392	−0.1028	−0.0714
Miles bike lanes < 1 M.	−0.0105	−0.0030	0.0048
Miles of bus routes < 0.5 M.	−0.0014	0.0013	0.0042
Bus stops < 0.5 M.	−0.0009	0.0010	0.0027
Rail stops < 0.5 M.	−0.0280	−0.0048	0.0173
Miles of rail lines < 0.5 M.	−0.0032	0.0064	0.0172
Intersections with 0.5 M	−0.0006	0.0001	0.0008

CBG population/sq. mile	−0.0000	0.0000	0.0000
CBG jobs/sq. mile	−0.0000	−0.0000	−0.0000
Work stops	−0.0005	0.0049	0.0108
Shopping stops	−0.0377	−0.0264	−0.0169
Social stops	−0.0261	−0.0145	−0.0037
Residential Low Density, 0-1/4 mile	−0.0035	−0.0010	0.0014
Residential Medium Density, 0-1/4 mile	−0.0043	−0.0015	0.0012
Residential High Density 0-1/4 mile	−0.0032	−0.0006	0.0019
Business Low Density 0-1/4 mile	−0.0041	0.0003	0.0050
Business High Density 0-1/4 mile	−0.0025	0.0002	0.0027
Industrial 0-1/4 mile	−0.0032	0.0000	0.0035
Residential Low Density, 1/4-1/2 mile	−0.0034	0.0003	0.0042
Residential Medium Density, 1/4-1/2 mile	−0.0035	0.0005	0.0043
Residential High Density 1/4-1/2 mile	−0.0045	−0.0004	0.0034
Business Low Density 1/4-1/2 mile	−0.0073	0.0012	0.0103
Business High Density 1/4-1/2 mile	−0.0045	−0.0001	0.0042
Industrial 1/4-1/2 mile	−0.0050	−0.0004	0.0046
Residential Low Density, 1/2-1 mile	−0.0069	−0.0020	0.0033
Residential Medium Density, 1/2-1 mile	−0.0039	0.0017	0.0075
Residential High Density 1/2-1 mile	−0.0058	−0.0002	0.0057
Business Low Density 1/2-1 mile	−0.0022	0.0135	0.0315
Business High Density 1/2-1 mile	−0.0091	−0.0028	0.0035
Industrial 1/2-1 mile	−0.0087	−0.0027	0.0032
(W) HH size	−0.0382	−0.0235	−0.0102
(W) HH vehicles	−0.0044	0.0094	0.0255
(W) HH bikes	−0.0014	0.0064	0.0148
(W) Male	−0.0203	0.0031	0.0237
(W) Age	−0.0006	0.0001	0.0008
(W) Income (000s)	0.0002	0.0004	0.0008
(W) College education	−0.0204	0.0000	0.0232
(W) Employed	−0.0471	−0.0228	0.0018
(W) Tour distance	−0.0007	0.0003	0.0014
(W) Tour crosses highway	0.0193	0.0455	0.0773
(W) Miles bike lanes < 1 M.	−0.0065	0.0021	0.0102
(W) Miles of bus routes < 0.5 M.	−0.0038	−0.0002	0.0032
(W) Bus stops < 0.5 M.	−0.0025	−0.0003	0.0020
(W) Rail stops < 0.5 M.	−0.0317	−0.0021	0.0276
(W) Miles of rail lines < 0.5 M.	−0.0159	−0.0042	0.0060
(W) Intersections with 0.5 M	−0.0011	−0.0002	0.0007
(W) CBG population/sq. mile	−0.0000	0.0000	0.0000
(W) CBG jobs/sq. mile	0.0000	0.0000	0.0000
(W) Work stops	−0.0080	0.0035	0.0137
(W) Shopping stops	0.0075	0.0204	0.0355
(W) Social stops	−0.0126	0.0118	0.0359
(W) Residential Low Density, 0-1/4 mile	−0.0027	0.0003	0.0035
(W) Residential Medium Density, 0-1/4 mile	−0.0022	0.0012	0.0046

(W) Residential High Density 0-1/4 mile	−0.0033	−0.0000	0.0033
(W) Business Low Density 0-1/4 mile	−0.0048	0.0014	0.0075
(W) Business High Density 0-1/4 mile	−0.0036	−0.0004	0.0030
(W) Industrial 0-1/4 mile	−0.0058	−0.0013	0.0033
(W) Residential Low Density, 1/4-1/2 mile	−0.0041	0.0004	0.0053
(W) Residential Medium Density, 1/4-1/2 mile	−0.0044	0.0003	0.0051
(W) Residential High Density 1/4-1/2 mile	−0.0034	0.0015	0.0067
(W) Business Low Density 1/4-1/2 mile	−0.0162	−0.0046	0.0065
(W) Business High Density 1/4-1/2 mile	−0.0069	−0.0013	0.0038
(W) Industrial 1/4-1/2 mile	−0.0048	0.0015	0.0075
(W) Residential Low Density, 1/2-1 mile	−0.0033	0.0023	0.0079
(W) Residential Medium Density, 1/2-1 mile	−0.0082	−0.0020	0.0040
(W) Residential High Density 1/2-1 mile	−0.0060	0.0000	0.0062
(W) Business Low Density 1/2-1 mile	−0.0309	−0.0107	0.0072
(W) Business High Density 1/2-1 mile	−0.0021	0.0047	0.0116
(W) Industrial 1/2-1 mile	−0.0033	0.0035	0.0102

TABLE A.12. Total Effects: SDM Model, Inverse Distance Spatial Weights Matrix

Dependent Variable: Non-auto Transportation Mode = 1			
Variable	Lower 95%	Posterior Mean	Upper 95%
HH size	−0.0080	0.0110	0.0301
HH vehicles	−0.1345	−0.1067	−0.0820
HH bikes	−0.0060	0.0070	0.0195
Male	0.0311	0.0583	0.0863
Age	−0.0055	−0.0043	−0.0033
Income (000s)	−0.0010	−0.0006	−0.0002
College education	−0.0174	0.0119	0.0401
Employed	−0.0557	−0.0234	0.0048
Tour distance	−0.0055	−0.0041	−0.0028
Tour crosses highway	−0.3087	−0.2630	−0.2197
Miles bike lanes < 1 M.	−0.0269	−0.0078	0.0120
Miles of bus routes < 0.5 M.	−0.0038	0.0032	0.0103
Bus stops < 0.5 M.	−0.0023	0.0025	0.0071
Rail stops < 0.5 M.	−0.0720	−0.0123	0.0442
Miles of rail lines < 0.5 M.	−0.0085	0.0162	0.0421
Intersections with 0.5 M	−0.0017	0.0002	0.0021
CBG population/sq. mile	−0.0000	0.0000	0.0000
CBG jobs/sq. mile	−0.0000	−0.0000	−0.0000
Work stops	−0.0015	0.0126	0.0262
Shopping stops	−0.0867	−0.0674	−0.0496
Social stops	−0.0646	−0.0373	−0.0101
Residential Low Density, 0-1/4 mile	−0.0087	−0.0024	0.0037
Residential Medium Density, 0-1/4 mile	−0.0104	−0.0039	0.0030

Residential High Density 0-1/4 mile	−0.0080	−0.0016	0.0051
Business Low Density 0-1/4 mile	−0.0103	0.0009	0.0126
Business High Density 0-1/4 mile	−0.0060	0.0004	0.0068
Industrial 0-1/4 mile	−0.0080	0.0001	0.0088
Residential Low Density, 1/4-1/2 mile	−0.0084	0.0009	0.0104
Residential Medium Density, 1/4-1/2 mile	−0.0091	0.0013	0.0108
Residential High Density 1/4-1/2 mile	−0.0110	−0.0010	0.0091
Business Low Density 1/4-1/2 mile	−0.0180	0.0031	0.0255
Business High Density 1/4-1/2 mile	−0.0110	−0.0003	0.0106
Industrial 1/4-1/2 mile	−0.0128	−0.0009	0.0110
Residential Low Density, 1/2-1 mile	−0.0176	−0.0051	0.0085
Residential Medium Density, 1/2-1 mile	−0.0098	0.0043	0.0191
Residential High Density 1/2-1 mile	−0.0152	−0.0005	0.0139
Business Low Density 1/2-1 mile	−0.0060	0.0342	0.0766
Business High Density 1/2-1 mile	−0.0237	−0.0072	0.0087
Industrial 1/2-1 mile	−0.0219	−0.0071	0.0082
(W) HH size	−0.0921	−0.0602	−0.0285
(W) HH vehicles	−0.0118	0.0237	0.0618
(W) HH bikes	−0.0034	0.0163	0.0372
(W) Male	−0.0502	0.0086	0.0616
(W) Age	−0.0016	0.0003	0.0020
(W) Income (000s)	0.0005	0.0011	0.0019
(W) College education	−0.0521	0.0000	0.0605
(W) Employed	−0.1152	−0.0580	0.0050
(W) Tour distance	−0.0018	0.0008	0.0035
(W) Tour crosses highway	0.0560	0.1158	0.1820
(W) Miles bike lanes < 1 M.	−0.0168	0.0053	0.0265
(W) Miles of bus routes < 0.5 M.	−0.0091	−0.0004	0.0085
(W) Bus stops < 0.5 M.	−0.0064	−0.0007	0.0051
(W) Rail stops < 0.5 M.	−0.0824	−0.0055	0.0693
(W) Miles of rail lines < 0.5 M.	−0.0389	−0.0107	0.0164
(W) Intersections with 0.5 M	−0.0027	−0.0005	0.0017
(W) CBG population/sq. mile	−0.0000	0.0000	0.0000
(W) CBG jobs/sq. mile	0.0000	0.0000	0.0000
(W) Work stops	−0.0191	0.0091	0.0349
(W) Shopping stops	0.0212	0.0522	0.0844
(W) Social stops	−0.0332	0.0307	0.0905
(W) Residential Low Density, 0-1/4 mile	−0.0071	0.0008	0.0089
(W) Residential Medium Density, 0-1/4 mile	−0.0055	0.0031	0.0112
(W) Residential High Density 0-1/4 mile	−0.0087	−0.0002	0.0082
(W) Business Low Density 0-1/4 mile	−0.0122	0.0036	0.0186
(W) Business High Density 0-1/4 mile	−0.0091	−0.0009	0.0075
(W) Industrial 0-1/4 mile	−0.0146	−0.0033	0.0081
(W) Residential Low Density, 1/4-1/2 mile	−0.0105	0.0011	0.0127
(W) Residential Medium Density, 1/4-1/2 mile	−0.0108	0.0009	0.0133
(W) Residential High Density 1/4-1/2 mile	−0.0086	0.0038	0.0165

(W) Business Low Density 1/4-1/2 mile	−0.0406	−0.0117	0.0163
(W) Business High Density 1/4-1/2 mile	−0.0172	−0.0034	0.0095
(W) Industrial 1/4-1/2 mile	−0.0124	0.0038	0.0188
(W) Residential Low Density, 1/2-1 mile	−0.0089	0.0060	0.0203
(W) Residential Medium Density, 1/2-1 mile	−0.0213	−0.0051	0.0102
(W) Residential High Density 1/2-1 mile	−0.0151	0.0002	0.0157
(W) Business Low Density 1/2-1 mile	−0.0743	−0.0271	0.0188
(W) Business High Density 1/2-1 mile	−0.0060	0.0120	0.0302
(W) Industrial 1/2-1 mile	−0.0077	0.0091	0.0263

Bibliography

Albert, J. and Chib, S. (1993). Bayesian Analysis of Binary and Polychotomous Response Data. *Journal of the American Statistical Association*, 88(422):669–679.

Anselin, L. (1988). *Spatial Econometrics: Methods and Models*. NATO Asi Series. Series E, Applied Sciences. Springer.

Anselin, L. (2001). Spatial econometrics. In Baltagi, B. H., editor, *A Companion to Theoretical Econometrics*. Blackwell, Malden, MA, blackwell edition.

Anselin, L. (2010). Thirty years of spatial econometrics. *Papers in Regional Science*, 89(1):3–25.

Anselin, L. and Lozano-Gracia, N. (2007). Errors in variables and spatial effects in hedonic house price models of ambient air quality. *Empirical Economics*, 34(1):5–34.

Arbia, G. (2006). *Spatial Econometrics: Statistical Foundations and Applications to Regional Convergence*. Springer, New York.

Bivand, R. and Gianfranco, P. (2015). Comparing Implementations of Estimation Methods for Spatial Econometrics. *Journal Of Statistical Software*, 63(18):1–36.

Bivand, R. S., Hauke, J., and Kossowski, T. (2013). Computing the Jacobian in Gaussian spatial autoregressive models: An illustrated comparison of available methods. *Geographical Analysis*, 45(2):150–179.

Chib, S. (1992). Bayes inference in the Tobit censored regression model. *Journal of Econometrics*, 51(1-2):79–99.

Cliff, A. and Ord, J. (1968). The problem of spatial autocorrelation.

Cliff, A. and Ord, J. (1973). Spatial autocorrelation.

Cliff, A. and Ord, J. (1981). Spatial processes: models & applications.

Fingleton, B. (1999). Estimates of Time to Economic Convergence: An Analysis of Regions of the European Union. *International Regional Science Review*, 22(1):5–34.

Geary, R. (1954). The Contiguity Ratio and Statistical Mapping. *The incorporated statistician*, 5(3):115–127.

LeSage, J. P. (2000). Bayesian estimation of limited dependent variable spatial autoregressive models. *Geographical Analysis*, 32(1):19–35.

LeSage, J. P. and Pace, R. K. (2009). *Introduction to Spatial Econometrics*. Chapman & Hall/CRC, Boca Raton, FL, 1 edition.

McMillen, D. (1992). Probit with spatial autocorrelation.

Moran, P. A. P. (1950). Notes on continuous stochastic phenomena. *Biometrika*, 37(1):17–23.

Pace, R. K., Barry, R., Slawson Jr, V. C., and Sirmans, C. F. (2004). Simultaneous spatial and functional form transformations. In *Advances in Spatial Econometrics*, pages 197–224. Springer.

Paelinck, J. H. P. and Klaassen, L. H. (1979). *Spatial Econometrics*. Saxon House.

R Core Team (2014). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.

Tobler, W. (1970). A computer movie simulating urban growth in the Detroit region. *Economic geography*.

Wilhelm, S. and Godinho de Matos, M. (2014). *spatialprobit: Spatial Probit Models*.