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Impacts of Transportation Infrastructure Proximity and Accessibility on Real Property Values

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Dedication

"All that I am, or hope to be, I owe to my angel mother."

—Abraham Lincoln

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Abstract

Investments in public infrastructure such as highways, airports, mass transit, and stadiums can increase adjacent property values, generating a value premium for private developers and adjacent property owners. A portion of this value can be "captured" as public revenue via property taxes to assist financing such improvements. States and local governments aim to anticipate and capture the economic value created by transportation accessibility. While value capture (VC) represents an opportunity for regional agencies to recapture some transportation infrastructure costs, it is not clear how much value is added by the infrastructure in a particular region. This research applies geographic weighted regression (GWR) to quantify the impacts of transportation infrastructure accessibility on real property values in El Paso, Texas. The presence of spatial nonstationarity and heterogeneity confirms that transportation infrastructure proximity and accessibility might generate a premium on real property values, but that such premium is not always positive, and is even negative in some areas. GWR shows that benefits from a transportation facility can be capitalized by parcels even if they are located away from the facility. Finally, GWR maps can assist to better VC policy development by estimating how much value is added by infrastructure projects throughout particular locations.

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Chapter 1: Introduction

Investments in public infrastructure such as highways, airports, mass transit, and stadiums can increase adjacent property values, generating a value premium for private developers and adjacent property owners. A portion of this value can be "captured" as public revenue via property taxes to assist financing such improvements. States and local governments aim to anticipate and capture the economic value created by transportation accessibility to fund capacity expansions. Value capture (VC) allows public agencies to recoup the private benefits on real property from investments in public infrastructure via the tax mechanism.

Infrastructure expenditures are financed primarily in three ways: (i) local government revenues (tax and non-tax), (ii) borrowing, and (iii) using funds from higher levels of government. As more vehicles with advanced fuel economies (e.g. hybrids) enter public and private fleets, fuel tax revenues and the Federal Highway Trust Fund (HTF) will continue to decline, limiting the funds provided to each state. Texas is no exception. Texas receives less revenue than what it pays to the HTF. Losses are expected through 2050 (Hall, 2012). If the trends for declining fuel tax revenues, increasing transportation needs, and higher infrastructure costs continue, the funding required to satisfy mobility needs is beyond what traditional sources, like the dated fuel tax, can supply.

Most of the non-roadway mechanisms for capturing the value premium are used by local governments, with a few being used by state departments of transportation (DOT). While VC represents an opportunity to recapture some transportation infrastructure costs, it is not clear how much value is added by infrastructure projects in a particular region. This research applies geographic weighted regression (GWR) econometric techniques to attempt to quantify the impacts of transportation infrastructure accessibility on real property values in El Paso, Texas.

Chapter 2 provides a review of the literature regarding infrastructure impacts on property values as well as GWR spatial econometric methods. Chapter 3 discusses data and methodology. Chapter 4 reports empirical results. Chapter 5 summarizes key findings and suggests topics for future research.

Chapter 2: Literature Review

Historically, land has been a mechanism to finance urban infrastructure (George, 1920). Value capture (VC) is the process by which increments in land values attributed to community efforts are recovered by the public sector. Recently, VC financing has attracted more attention due to issues with traditional funding sources, but, according to Batt (2001), still remains in its early-to-mid stages of development. Peterson (2009) documents recent VC case studies in the developing and developed world in the context of public-private partnerships (P3s). Levinson and Istrate (2011) explored how the positive reinforcement among land value, accessibility, and transportation infrastructure generates value and can be used to fund transportation in a sustainable manner through VC policies. Rybeck (2004) compares VC using a split-rate property tax with tax-increment financing (TIF) techniques.

Tax Increment Financing is a VC technique that generates cash flows from increases in real property values in a development or redevelopment project via the property tax mechanism. The expected cash flow is used to finance the project costs. Although TIF is commonly used by local governments as a tool to promote economic development, its use for transportation finance has been more limited (Zhao et al. 2011). Texas is one of the first states to develop a legislative framework that allows municipalities and counties to set up Transportation Reinvestment Zones (TRZ), a VC technique similar to TIFs, but specifically designed to fund transportation. Texas law defines a TRZ as a designated continuous zone around a transportation improvement where a local government can commit a portion of the property tax revenue increases to fund the improvement. Vadali et al. (2009) developed a methodology to quantify VC revenue potential. It uses a spreadsheet-based application which uses cadastral parcels from ArcGIS and financial parameters using Monte Carlo simulation to account for risk and market conditions. As of 2013, there are five cases in Texas where the TRZ mechanism has been used or is being considered.

Many studies report evidence that investments in public infrastructure can increase adjacent property values, generating a value premium for adjacent property owners. In El Paso, Fullerton and Villalobos (2011) apply a hedonic pricing model to a random sample of 562 housing units, and test the significance of 22 variables related to structural and locational features. Results indicate that housing prices are negatively impacted by distances from parks, employment centers, and international bridges. A similar effort for Juarez, Mexico, indicates that major avenues and accessibility do not always improve housing values (Fierro et al. 2009). Assessing estimates of cadastral values, forecasting methods, and their accuracy is an essential step to quantify VC, TIF, and municipal revenues. In El Paso, Arnold Cote et al. (2010) compared four typical econometric techniques to forecast property taxation with a random walk and a random walk with drift. The random walk with drift outperformed all four techniques for both commercial and industrial properties. Anselin and Lozano-Gracia (2012) note that by considering spatial variables, in the form of distance to amenities, the predictive performance of different models used in real property valuation improves significantly.

Spatial econometric techniques have proven useful in studies where spatial dependence is present (Dubin, 1988; Basu and Thibodeau, 1998). Such techniques allow modeling and testing spatial autocorrelation and spatial heterogeneity to assess spillover effects and dependence between observations that are in close geographic proximity (e.g. real property parcels). Formalized by Paelinck and Klaassen (1979) and Anselin (1988), the evolution of spatial econometrics in recent years is extensive (Anselin, 2010; Elhorst, 2010). By applying spatial econometric models, Zhang and Wang (2013) find that housing prices in Beijing capitalize positive premia from distances to the nearest metro station, health centers, and sports facilities.

Concas (2013) applies a spatial autoregressive (SAR) difference-in-differences estimator, and finds that houses near limited-access roadways exhibit greater price resilience during and after market downturns. Results indicate price gains for single-family homes located near to limited-access roadways from 4.6% to 5.2% over their controls. These price differentials

persisted 4 to 5 years subsequent to opening the roadway. Chernobai et al. (2011) analyze spatial effects on home prices in Los Angeles. Results indicate that the premia on house prices is maximized at 0.4 miles away from the highway and diminishes as the distance increases beyond the 0.4 miles. Prior to the opening, distance from the highway was not statistically significant. Also, the premia fades away in years subsequent to opening the highway to the public.

Accessibility to transit, work, and non-work destinations tend to raise real property values. Several studies quantify accessibility using distance-based and driving time variables (Diao and Ferreira, 2010; Shin et al. 2007). Vadali (2008) examines impacts of toll roads on residential property values over 20 years in Dallas, Texas using traditional and spatial econometrics. Results indicate that accessibility benefits are capitalized by properties located in a 0.25–1.00 mile radius. Srour et al. (2002) use hedonic models to explore the relationship of accessibility (e.g. travel-time) with property valuations also in Dallas using (i) a land value model and (ii) a total property value model. Results indicate that job accessibility and distance to central business districts (CBD) raise residential land values. Siethoff and Kockelman (2002) analyze parcel values along the U.S. 183 corridor in Austin, Texas using: (i) a land value model, (ii) an improvement value model, and (iii) a total property value model. Freeway proximity, corner parcels, and timing of completion are found to significantly impact parcel values.

Geographic Weighted Regression (GWR) accounts for spatial heterogeneity by generating individual regression equations in subsamples of a geographic dataset. Unlike the average coefficients estimated by ordinary least squares OLS (i.e. global coefficients), GWR estimates location-dependent distributions for coefficients around a particular point or epicenter (i.e. local coefficients). GWR assumes that observations closer to the epicenter of each subset have greater weights in parameter estimation than more distant ones (Brunsdon et al. 1998; Fotheringham et al. 1997, 2002; Brunsdon et al. 2010). Efthymiou et al. (2013) applies OLS, SAR, and GWR to determine the locations for transportation mobility centers. Results show that the GWR model fits the data best, and it is the only model that solves the spatial

autocorrelation of the residuals. Number of residents, points of interest, bus routes, average vehicle speed, and length of the road network are the most significant coefficients. Löchl and Axhausen (2010) also apply OLS, SAR, and GWR to model residential asking rent prices in Zürich, Switzerland. Spatial explanatory variables include distance-based and driving time accessibility measures. OLS outperforms the other two on model fit, but SAR and GWR techniques are superior when spatial correlation is present.

Du and Mulley (2007) analyze the impact of transportation accessibility on land values using GWR for VC purposes in the United Kingdom. The findings indicate that accessibility generally has a positive effect on land value. In some areas, however, the effect was either negative or null, suggesting that indiscriminately applied VC policies would be inappropriate. Legg and Bowe (2009) apply OLS and GWR to a sample of 93 homes listed in Michigan. The GWR results have superior descriptive statistics. Listing prices are higher for lots located closer to downtown and farther from rural towns; furthermore, higher property tax rates near downtown may discourage new developments in this area.

Spatial spillover effects and spatial dependence between observations also impact the marginal prices of structural housing characteristics (e.g. the price of an additional bedroom in two different neighborhoods) particularly within large metropolitan regions. GWR has proven useful to account for and address such spatial effects (Bitter et al. 2007). GWR has also been used in combination with discrete-choice datasets to anticipate land use changes, which is helpful to forecast VC, TIF, and municipal revenues from new development. Wang et al. (2012) develop a multinomial logit GWR to model five categories of land use change in Austin, Texas. After accounting for parcel geometry, accessibility, population density, distance to downtown and various roadway types, results indicate that a 1% increase in proximity of a vacant parcel to the nearest freeway increased the probability of residential development by 1.2%, and the same increase in distance to a major arterial increased the probability by 1.8%. Additional GWR studies include Páez et al. (2007), Yu et al. (2007), Farber and Yeates (2006), and Kestens et al. (2006).

One of the critiques of GWR is that multivariate parameter estimates might be inherently correlated, making the interpretation of map patterns for individual terms difficult. However, spatial dependence remains an issue even after including spatial independent variables in OLS (Löchl, 2007). Getis (2007) suggests the following tests, among others, to check for spatial autocorrelation:

- Moran's I (global covariance representation),
- Getis and Ord's G_i and G_i (local cluster representations),
- Ord and Getis's O (considers global autocorrelation), and
- ρ, λ (autoregressive coefficients in various regression representations).

As noted throughout this chapter, there are several advantages of analyzing spatial autocorrelation, such as assessing the strength of the spatial effects on any variable; evaluating spatial stationarity, spatial heterogeneity, and distance decay; and allowing spatial hypothesis testing. All these advantages represent potential improvements to the efficiency and accuracy of modeling cadastral values and to quantifying the impacts of transportation infrastructure accessibility on real property values. This may translate into better VC and TIF policy development, and into better quantification of VC, TIF, and municipal revenue gains.

Chapter 3: Methodology and Data

The hypothesis tested is that transportation infrastructure proximity and accessibility impact real property values in El Paso, Texas. The procedure involves the application of hedonic price models using least squares regression analysis. Hedonic studies have been widely used to analyze the impact of transit on property values (Rosen, 1974). Prior empirical evidence indicates that the magnitude of the impacts on property values vary over space (Anselin and Lozano-Gracia, 2012). Tests for spatial autocorrelation and spatial heterogeneity are used to assess spillover effects and dependence among close parcels.

3.1 Global and Local Regressions: OLS and GWR

The methodology starts by estimating three hedonic equations: (1) a total-value model, (2) an improvement-value model, and (3) a land-value model similar to Siethoff and Kockelman (2002). Subsequently, these three specifications are assessed using GWR. Data collected include 2013 certified cadastral parcel records for real property for El Paso County, with transportation accessibility and socioeconomic characteristics obtained from GIS. The total-value model consists of all land-value and improvement-value variables and a constant, as shown in Equation 1. The improvement-value model includes all attributes related to structural characteristics of improvements or buildings (e.g. living area, number of bathrooms, number of bedrooms, etc.) as shown in Equation 2. The land-value model employs characteristics exclusively related to land parcels (e.g. lot size in acres, etc.) as shown in Equation 3.

1. Total-value model:

$$TotValue_i = \beta_0 + \sum_{i}^{n} \beta_{i\,Impr} X_{i\,Impr} + \sum_{j}^{n} \beta_{j\,Land} X_{j\,Land} + \epsilon_i \qquad (1)$$

where

$TotValue_i =$ dependent variable related to the total taxable value of a parcel (i.e. the taxable value for the land plus the improvement);

$X_{i,\,Impr} =$ vector of variables related to the characteristics of the improvement;

$X_{j,\,Land} =$ vector of variables related to the characteristics of the land; and

$\epsilon_i =$ error term at point i.

2. Improvement-value model:

$$ImprValue_i = \beta_0 + \sum_{i}^{n} \beta_{i\,Impr} X_{i\,Impr} + \epsilon_i \qquad (2)$$

where

$ImprValue_i$ = dependent variable related only to the taxable value of the improvement within a parcel i; and

$X_{i,\,Impr}$ = vector of variables related to the characteristics of the improvement.

3. Land-value model:

$$LandValue_i = \beta_0 + \sum_{j}^{n} \beta_{j\,Land} X_{j\,Land} + \epsilon_i \qquad (3)$$

where

$LandValue_i$ = dependent variable related only to the taxable value of the land corresponding to a parcel i; and

$X_{j\,Land}$ = vector of variables related to the characteristics of the land.

The GWR method is an enhancement of the weighted least-squares technique. It accounts for spatially varying relationships by generating individual regression functions in subsets of a specific location with coordinates (u_i, v_i). GWR incorporates a spatial weights matrix, which varies by location, estimating a local regression for each observation in the dataset, as shown in Equation 4 (Brundson et al. 2010). In Equation 4, observations located closer to the epicenter (u_i, v_i) of each subset have greater weights in parameter estimation than more distant ones.

$$y_i = \beta_0(u_i, v_i) + \sum_{k} \beta_k(u_i, v_i) X_{ik} + \epsilon_i \qquad (4)$$

where

y_i = dependent variable for a specific model (i.e. total values, improvement values, and land values);

(u_i, v_i) = spatial coordinates of a point i (i.e. geometric centroid of each parcel);

k = number of variables;

$\beta_k(u_i, v_i)$ = realization of function $\beta_k(u, v)$ at point i; and

X_{ik} = value of explanatory variable k at point i.

The spatial weights matrix is determined including observations for the dependent and explanatory variables falling within the bandwidth around a specific point (u_i, v_i). The bandwidth can be determined by distance, number of neighbors, or by a Gaussian kernel process. Kernel bandwidths can be fixed or adaptive depending on the density of observations at a particular location. The weights of the estimator used in this model are conditioned on the location coordinates (u_i, v_i):

$$\hat{\beta}(u_i, v_i) = (X^T W(u_i, v_i) X^{-1})\, X^T W(u_i, v_i) Y_i \qquad (5)$$

where

$\hat{\beta}(u_i, v_i)$ = vector of estimated parameters at location coordinates (u_i, v_i);
X^T = the transpose of matrix X number of variables;
$W(u_i, v_i)$ = n by n spatial weight matrix, which varies by location (u_i, v_i);
X = n by k matrix of covariates; and
Y = n by 1 vector of dependent values (across n observations).

Adaptive kernel bandwidths are typically preferred when some of the regression points are not uniformly distributed over space (i.e. the data are sparse). When the data are sparse, the spatial weight matrix is estimated using a small number of data points resulting in fairly large standard errors for the parameters. In order to minimize the standard errors, adaptive kernels adjust the bandwidth to include the same number of observations in a consistent manner regardless of their density variation across space. The bandwidth of the kernels is determined by minimizing a corrected Akaike Information Criterion (AIC_c) or a cross validation (CV) score regardless of the kernel bandwidth selected (i.e. fixed or adaptive). The formula for the AIC_c, as applied in Hurvich et al. (1998) is:

$$AIC_c = 2n \log_c(\hat{\sigma}) + n \log_c(2\pi) + n \left[\frac{n + tr(S)}{n - 2 - tr(S)}\right] \qquad (6)$$

where

AIC_c = information distance between the true and the fitted models;
n = number of data points;
$\hat{\sigma}$ = estimated standard deviation of the residuals; and
$tr(S)$ = trace of hat matrix S (also called projection matrix, which maps the vector of observed values to the vector of fitted values); and
S = $X(X^T X^{-1})\, X^T$.

The formula for the CV score, as applied in Fotheringham et al. (2002) is:

$$CV = \sum_{n=1}^{N_{obs}} \sum_{j=0}^{j} \left(I_{\neq n,j} - \hat{P}_{\neq n,j}(b)\right)^2 \qquad (7)$$

where

$CV =$ cross-validation score minimized to find the optimal bandwidth value or number of nearest neighbors;

$I_{\neq n,j} =$ indicator variable for data points other than n, which equals 1, if parcel n is of land use type j, and 0 otherwise; and

$\hat{P}_{\neq n,j} =$ estimated probability for parcel n with land use type j.

The lower the AIC_c and the CV score, the closer the fitted model is to the true model. However, problems with local multicollinearity might prevent both the AIC_c and CV methods from resolving an optimal distance or number of neighbors. In such instance, the calculation needs to be done manually using the following kernel estimator as described by Efthymiou et al. (2013):

$$\hat{f}(x) = \frac{1}{nh} \sum_{i=1}^{n} K\left(\frac{x - X_i}{h}\right) \qquad (8)$$

where

$\hat{f}(x) =$ density;
$n =$ number of data points;
$h =$ bandwidth; and
$K =$ kernel.

Finally, the Getis and Ord's G_i test is applied to check for spatial autocorrelation in the residuals as suggested in Getis (2007).

3.2 Data Collection and Study Area

El Paso County consists of a polycentric surface of 1,015 square miles with a population of 827,398 according to the 2012 Census estimate. El Paso County includes the municipalities of El Paso, Horizon, Fabens, Clint, San Elizario, Canutillo, Socorro, and Anthony. Although the New Mexico cities of Sunland Park and Anthony are part of the metropolitan region, they are not within the El Paso County jurisdictional limits, so they are not analyzed. El Paso Central Appraisal District (EPCAD) maintains parcel records and their total taxable values, which

account for exemptions. EPCAD also has separate listings for land and improvement values. Only real property is allowed to be within a TRZ. Given that, all personal property is excluded, such as mobile homes or inventory. Non-taxable parcels (e.g. government, churches, etc.) are classified as TRZ not eligible. EPCAD also lists the age of the improvement, if any, on a given parcel and the year since any renovations were made to the original structure. Additional data collected from EPCAD include: lot acreage, square footage of improvements, square footage of living area, bedrooms, bathrooms, air conditioning, and garages.

The *2013 Property Classification Guide* (Combs, 2013), used by EPCAD for electronic appraisal roll data submissions to the Texas Comptroller of Public Accounts, is used to determine which parcels are taxable, plus property classification and land use categories, as described in Table 3.1. The 2013 EPCAD certified cadastral roll included a total of 352,077 parcels that occupy 460,532 acres of land within El Paso County. The predominant land use is *Single-family*, which accounts for 56% parcels of the total sample; *Multi-family* accounts just for 2.4%; *Other*-residential for 5.3%; *Commercial* for 30%; *Industrial* for less than 0.5%; *Qualified open space for 2.8%;* and *TRZ not eligible* (i.e. non-taxable) for 3.1% of the total parcels in the county (Figure 3.1). The range of total taxable values for the entire county is illustrated in Figure 3.2. In order to determine the vacancy status of a parcel, regardless of its land use classification, the improvement attribute was used. Parcels with improvement values of zero are classified as vacant. According to the 2013 data, 133,799 parcels are vacant, mostly located on the east side of the county, and 218,280 parcels are developed. Vacancy was verified using 2013 aerial imagery in GIS (Figure 3.3).

A parcel's accessibility to the transportation infrastructure is an important element that impacts property values. In this study, accessibility for each parcel is determined as the distance from the front edge of each parcel to the nearest interstate, freeway, and major arterial measured in feet using the polygon-to-nearest-line GIS tool. Also, accessibility for each parcel is determined as the driving-time measured in minutes from the geometric centroid of each parcel to the nearest port-of-entry (POE) and major shopping centers. Table 3.2 illustrates

the descriptive statistics for these and all the other variables considered. The distance to each feature was estimated using Euclidean perpendicular distance from the centroid of each parcel to the centerline of a transportation facility. The driving times were estimated calculating driving-time areas using the actual street network also in GIS (i.e. the area around a location that can be reached within x-minutes).

El Paso County has 145 miles of interstate highways, 216 miles of freeways, and 482 miles of major arterials, as measured at the centerline of each transportation facility. In divided highways, centerline miles were calculated by measuring the center of all traffic lanes for each direction of travel. In undivided highways, centerline miles were calculated by measuring the center of all traffic lanes for both directions. There are 688 miles of urban transit in El Paso County, measured in a similar manner, which are not analyzed in this study. There are four international POEs in the County: 1) Bridge of the Americas, 2) Paso Del Norte Bridge, 3) Ysleta International Bridge, and 4) Stanton International Bridge. Fullerton and Villalobos (2011) find that proximity to such POEs positively impacts housing prices. Figure 3.4 shows the transportation network, POEs, and shopping centers considered in this study.

Table 3.1. Land Use Shares

Land use categories	Dummy variable description	Total		Developed		Vacant	
		No. of Obs.	% from County	No. of Obs.	% from Total	No. of Obs.	% from Total
Single-family	Homes on tracts of land or platted lots for residential purposes (e.g. houses, townhouses, condominiums, and owner-occupied duplexes that are homesteads). Include categories A1, C1, and O2.	198,574	56.4%	185,291	93.3%	13,283	6.7%
Multi-family	Residential parcels with two or more improvements under single ownership (e.g. apartment complexes, duplexes, triplexes, etc.). Excludes owner-occupied duplexes that are homesteads. Include categories A5, B1, B2, B3, B4, B5, and B6.	8,373	2.4%	8,370	3.8%	3	0.0%
Other-residential	Residential parcels that do not fall under the single- or multi-family categories, but that have taxable accounts (e.g. common areas in condos, neighborhood associations, lots used by mobile homes, etc.). Includes: A2, A3, A4, A6, A7, A8, A9, C3, C5, C6, C7, C8, C9, and O1.	18,808	5.3%	11,864	5.4%	6,944	36.9%
Commercial	Land and improvements associated with businesses selling goods or services (e.g. office buildings, hotels, gas stations, retail stores, utilities, railroads, multi-family rentals, and vacant lots for sale still owned by developers). Includes: A5C, B7, B8, B9, C2, C4, F1, F3, F4, F5, J2, J3, J4, J5, J6, J7, J8, and J9.	105,611	30.0%	9,772	4.5%	95,839	90.7%
Industrial	Land and improvements of businesses that add value to a product through development, manufacturing, fabrication or processing. Includes only category F2.	162	0.1%	147	0.1%	15	9.3%
Qualified open space	Combines all acreage qualified for productivity valuation and farm and ranch improvements on qualified open-space (e.g. timberland, agricultural, desert, farm and ranch improvements, etc.). Includes: D1, D2, D3, D4, D5, D6, D7, D8, D9, E1, and E2.	9,739	2.8%	771	0.4%	8,968	92.1%
TRZ not eligible	Non-taxable (e.g. government parcels, churches, universities, schools, mobile homes, personal property, etc.). Includes: F0, L1, L2, M1, M2, M3, M4, M5, N1, S, Y8, Y9, Z0, Z1, Y-7, Z2, Z3, Z4, Z5, Z6, Z7, and EX Z9.	10,810	3.0%	2,063	1.0%	8,747	80.9%
Total	**All parcels within the El Paso County**	**352,077**	**100.0%**	**218,280**	**62.0%**	**133,799**	**38.0%**

Source: 2013 El Paso Central Appraisal District.

Table 3.2. Descriptive Statistics for 2013 Data: 352,077 parcels

Variable	Description	Min	Max	Median	Mean	SD
Dependent variables						
TotValue$_i$	Total value	$0.00	$373,547,000	$56,339	$92,365	$776,662
ImprValue$_i$	Improvement value	$0.00	$371,326,965	$56,641	$79,500	$771,329
LandValue$_i$	Land value	$0.00	$24,924,930	$13,648	$27,187	$201,756
Explanatory variables common in all models						
DistInterst	Distance to nearest interstate (ft.)	0.00	122,386.00	18,274.67	27,204.00	24,283.00
DistFreeways	Distance to nearest freeway (ft.)	0.00	143,086.07	9,082.80	17,485.51	19,575.90
DistMajArteri	Distance to nearest major artery (ft.)	0.00	61,966.25	1,880.50	6,714.33	10,751.48
ShopC_DTime	Driving-time to nearest shopping centers (minutes)	1.00	62.00	11.00	17.20	12.85
POE_DTime	Driving-time to nearest port-of-entry (minutes)	1.00	61.00	20.00	23.75	12.12
PopDens_CY	Pop. density per block	0.20	26,171.00	1,666.50	3,421.00	3,578.00
Renter_CY	Renter occupied housing units	0.00	1,436.00	105.00	172.00	160.00
Vacant_CY	Number of improvements not occupied per block (empty bldgs.)	0.00	182.00	31.00	41.77	42.40
Unemp_CY	People 16 and older unemployed per block	0.00	374.00	44.00	63.00	62.00
PCI_CY	Income per-capita per block	0.00	$54,598.00	$12,413.00	$15,172.00	$8,212.00
MP35003a_B	People with 3 or more air trips/yr/block	0.00	510.00	64.84	87.00	73.00
Land-only explanatory variables						
LandAcres	Lot size (acres)	0.00	5,760	0.205	1.31	19.5
Improvement-only explanatory variables						
ImpSize	Improvement area (square ft.)	0.00	3,000,031.00	1,426.00	3,005.00	23,937.00
LivgArea	Living area (square ft.)	0.00	953,000.00	1,089.00	1,480.00	8,198.00
Stories	Number of stories	0.00	21.00	1.00	0.60	0.50
StoriesSqr	Number of stories squared	0.00	441.00	1.00	0.63	0.97
Baths	Number of bathrooms	0.00	13.00	0.00	1.00	1.10
BathSqr	Number of bathrooms squared	0.00	169.00	1.00	2.20	3.80
Beds	Number of bedrooms	0.00	12.00	0.00	0.80	1.50
BedSqr	Number of bedrooms squared	0.00	144.00	0.00	2.90	5.60
ImpAge	Age of improvement (years)	0.00	213.00	10.00	20.00	24.00
ImpAgeSqr	Age of improvement squared (years)	0.00	45,369.00	100.00	988.00	1,747.00
Yrs_SRemod	Years since last remodeling	0.00	153.00	10.00	19.64	23.51
Depreciable	Depreciable life of improvement (%)	0.00	100.00	98.00%	90.05%	14.25%
Vacant	Parcel without an improvement (DV)	0.00	1.00	1.00	0.40	0.50
Garage	Garage (DV)	0.00	1.00	0.00	0.00	0.10
Air	Air conditioning (DV)	0.00	1.00	1.00	0.50	0.50

Sources: 2013 El Paso Central Appraisal District and 2013 Esri Demographic, Consumer, and Business Data.

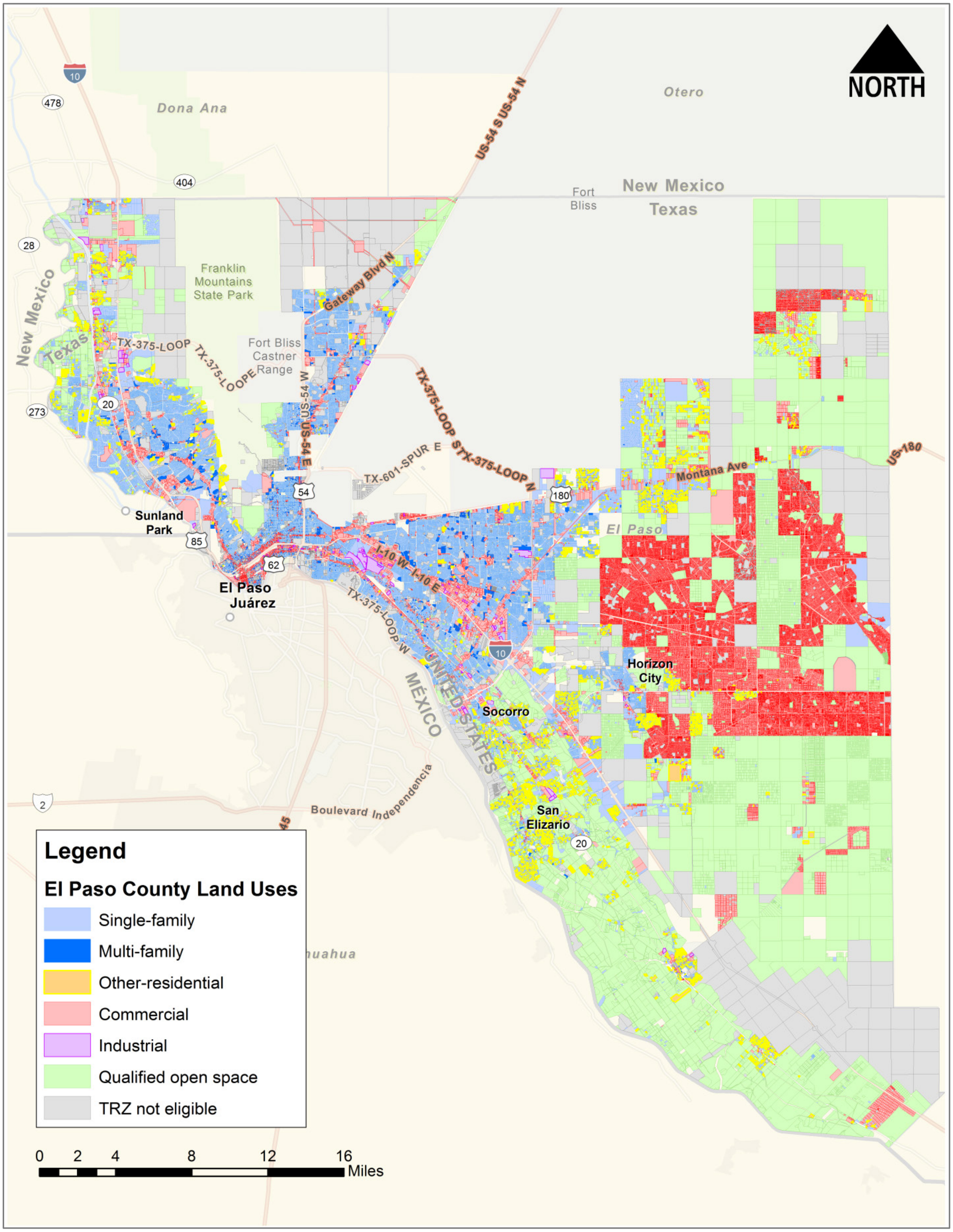


Figure 3.1. 2013 Cadastral Data and Land Uses in the El Paso County Jurisdiction.

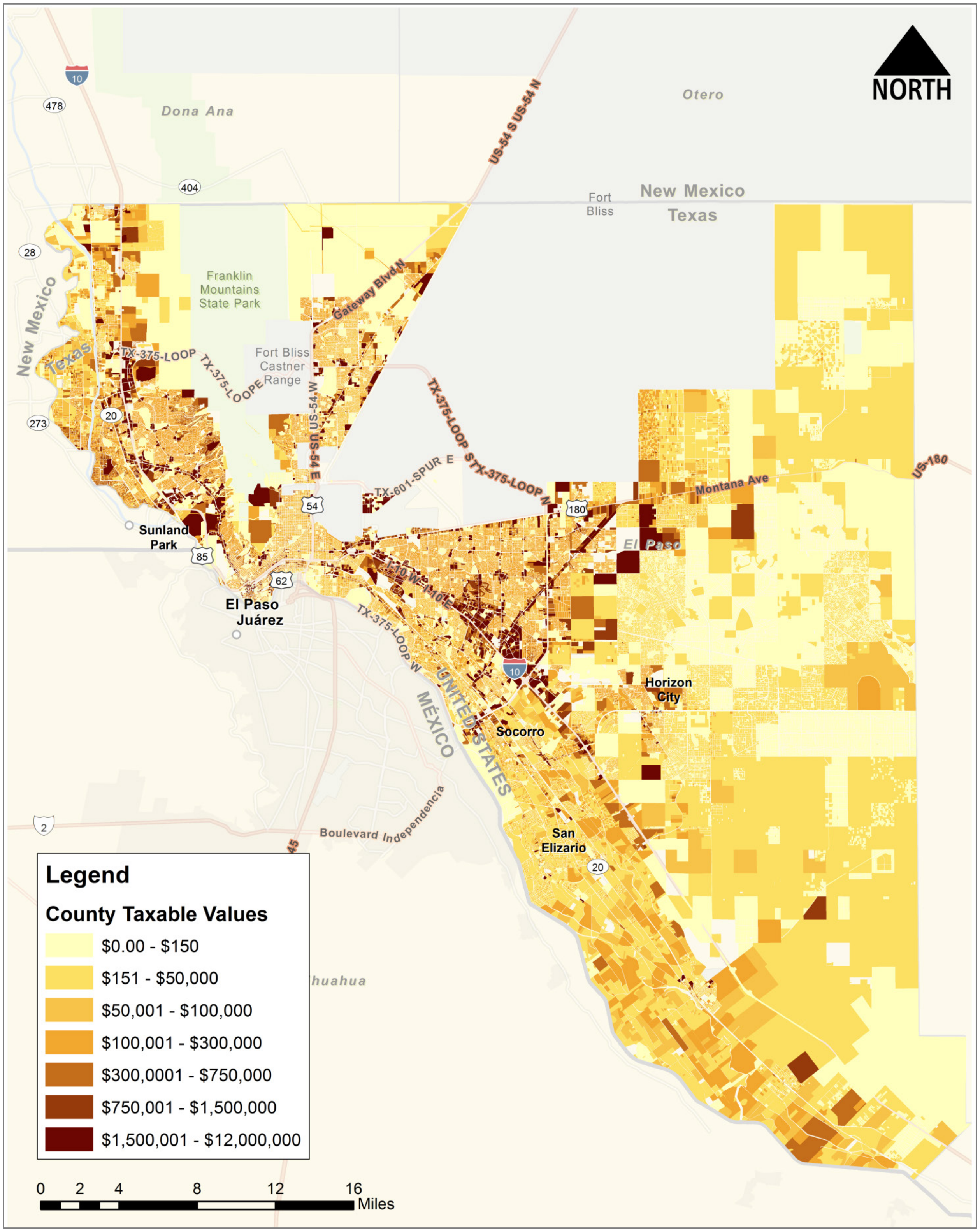


Figure 3.2. 2013 El Paso County Total Taxable Values.

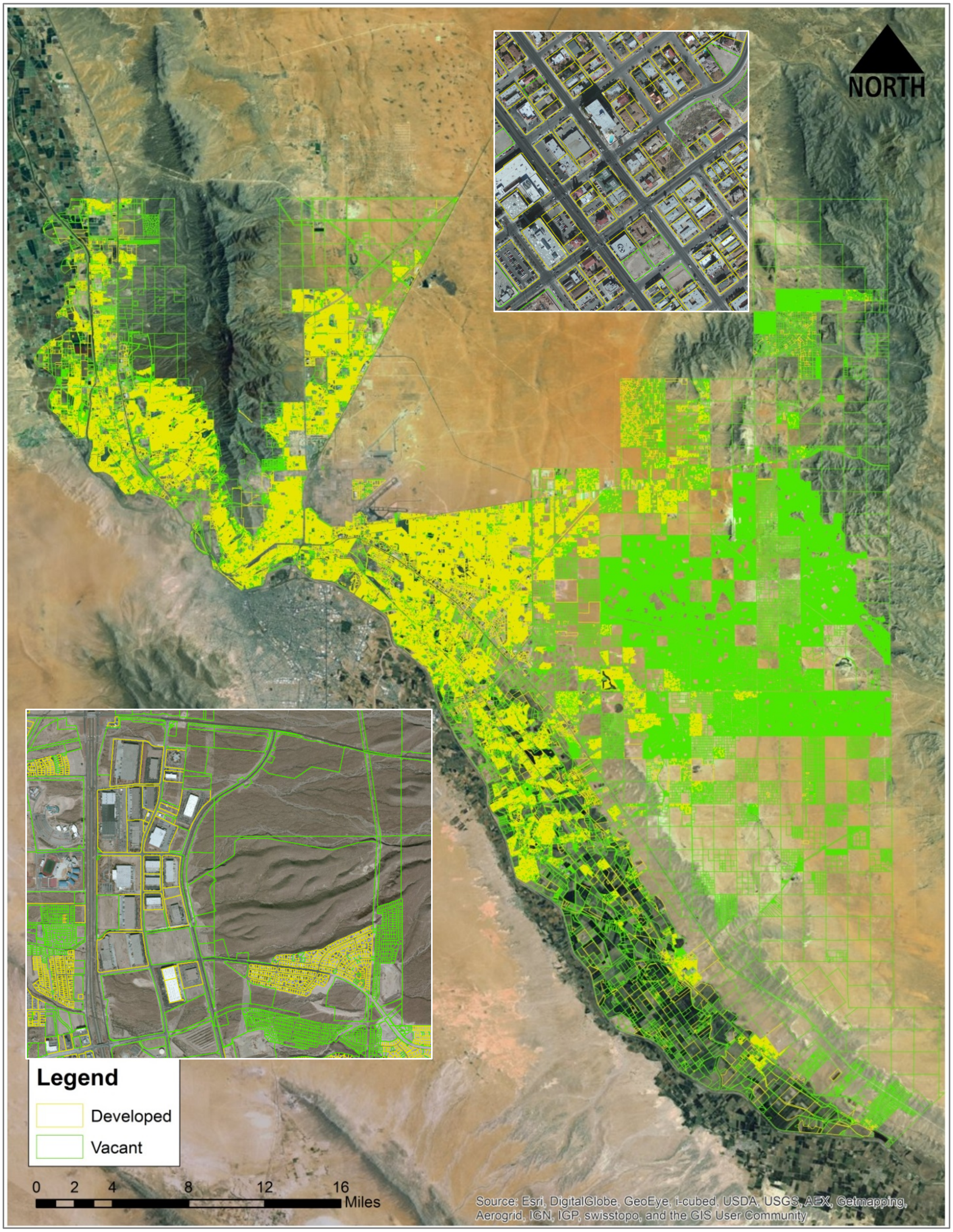


Figure 3.3. Vacant Parcels in El Paso County.

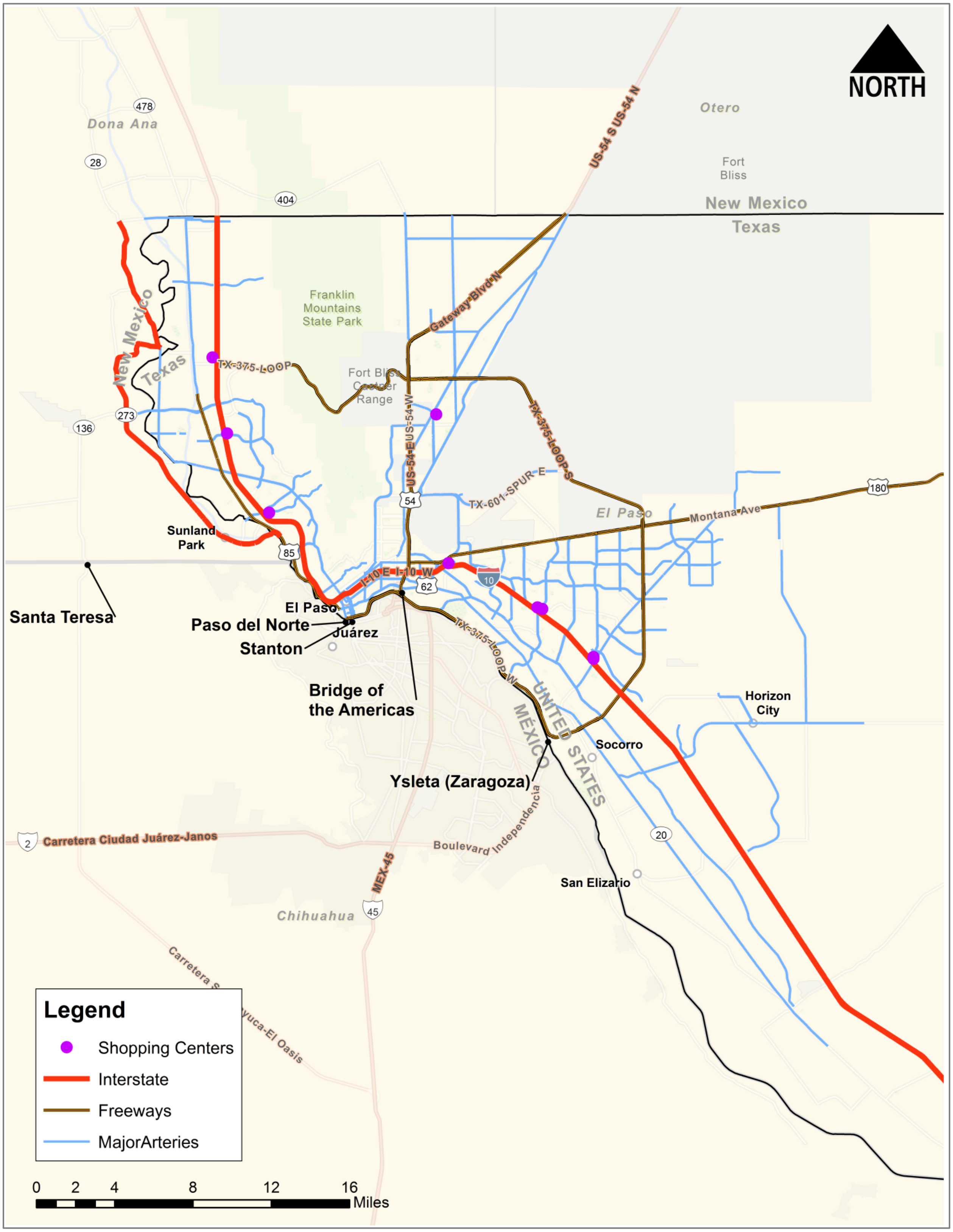


Figure 3.4. Transportation Infrastructure System in El Paso County.

Chapter 4: Empirical Analysis

This chapter summarizes the empirical results for the three hedonic equations: (1) the total-value model, (2) the improvement-value model, and (3) the land-value model for each of the seven property and land use categories analyzed. The impacts of transportation accessibility on property values are first evaluated using least squares. Once a statistically significant OLS model (i.e. a global model) is identified, then its GWR counterpart is developed (i.e. a local model). The hedonic equations control for elements that capture the utility of structural, neighborhood, and locational characteristics of a parcel. However, the text and figures in this chapter focus only on the variables testing the hypothesis that transportation infrastructure proximity and accessibility impact real property values.

Results from OLS include estimation of the coefficients, standard errors, t-statistics, and probability values. Results also include robust standard errors (*Robust SE*), robust t-statistics (*Robust t*), and robust probabilities (*Robust Prob*). Robust estimators are accurate even in the presence of nonstationarity or inconsistent residual variance (heteroskedasticity), and they are used to determine if an explanatory variable is significant (White, 1980). Variables that are not significant in the OLS estimation are excluded from the GWR. A significant Koenker Bruesch-Pagan (BP) test indicates that problems with nonstationarity or heteroskedasticity are present (Koenker, 1981). When the variance inflation factor (VIF) is larger than 7.5 for a variable, local multicollinearity is a problem, and such variables are excluded from GWR. In order to mitigate local multicollinearity issues associated with insufficient variation around the epicenter (u_i, v_i), adaptive kernels are determined setting the bandwidth to 1,000 neighbors, as Wang et al. (2012). Dummy variables and variables with spatial clustering of very similar values (i.e. number of stories, bedrooms, and baths) are squared or removed from GWR also to counter local multicollinearity.

The statistical diagnostics from OLS include R^2 and AdjR^2 as measures of the global model performance. When the Koenker BP statistic is significant, the Joint F-Statistic is not reliable, and the Joint Wald Statistic is used to determine the overall significance of the model. A significant

Jarque-Bera statistic indicates that the residuals are not normally distributed. The diagnostics from GWR include results from a baseline global model (i.e. residual squares, sigma, R^2, AdjR^2, and AIC_c). Furthermore, GWR summary statistics describe the variability range of the local coefficients and their standard errors (i.e. mean, minimum, and maximum). In GWR, it is necessary to visualize the local coefficients in maps to better interpret nonstationarity. Local coefficient maps are presented for each variable testing the hypothesis to better understand the local variation and magnitude of the impacts on property values. Given the large number of explanatory variables, it would be impractical to present maps for all of them.

4.1. SINGLE-FAMILY

4.1.1. Single-family Total Value Model

The total value sample for single-family has 198,574 observations (56.4% of the total population). The dependent variable is total taxable value ($TotValue_i$). Table 4.1 presents the results for the 21 independent variables plus the intercept term, in which 17 parameters are statistically significant according to their robust 95% confidence interval. For every additional person with 3 or more air-trips per year, results for *Mp35003a_B* indicate an increase of $37.50 in *TotValue. DistInterstate* indicates that *TotValue* decreases $0.66 for every foot a parcel is located away from the nearest interstate. *DistFreeways* indicates a similar decrease of $0.72 per foot. *DistMajorArteries* is not significant in this model. *POE_DrivingTime* indicates that *TotValue* increases $1,297 for every driving minute a single-family property is located away from the nearest POE. This runs counter to the findings in the random sample of Fullerton and Villalobos (2011), which indicates that as distance to a POE increases, the list price of a housing unit decreases. *ShopC_DrivingTime* indicates that *TotValue* decreases $884 for every minute it takes to drive to the nearest shopping center. Adjusted R^2 indicates that the total value model explains 47.6% of the variation. The significant Jarque-Bera statistic suggests that residuals are not normally distributed. The Koenker BP statistic is significant indicating that nonstationarity and heteroskedasticity are an issue. The Joint Wald Statistic states that the overall model is significant.

Table 4.1. Single-family—Total Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	1203.06	4123.42	0.29	0.77	22619.90	0.05	0.96	--------
ImpAge	-105.95	17.55	-6.04	0.00*	21.26	-4.98	0.00*	4.80
Air	-2285.74	759.16	-3.01	0.00*	1209.19	-1.89	0.06	2.22
$Baths^2$	1858.36	49.96	37.20	0.00*	193.23	9.62	0.00*	1.30
$Bedrooms^2$	1083.94	36.05	30.07	0.00*	89.58	12.10	0.00*	1.52
Garage	1545.81	1198.30	1.29	0.20	1015.83	1.52	0.13	1.26
Depreciable	867.51	30.75	28.22	0.00*	25.67	33.79	0.00*	3.88
LandAcres	7313.27	62.06	117.83	0.00*	1886.81	3.88	0.00*	1.03
ImpSize	34.39	0.12	285.58	0.00*	2.19	15.67	0.00*	1.30
Stories	-70389.95	2582.89	-27.25	0.00*	20495.23	-3.43	0.00*	11.56
Vacant	-51719.14	2609.16	-19.82	0.00*	20969.16	-2.47	0.01*	11.94
PopDens_CY	-0.58	0.07	-8.82	0.00*	0.13	-4.28	0.00*	1.40
Renter_CY	4.28	1.37	3.13	0.00*	2.53	1.69	0.09	1.43
Vacant_CY	42.00	7.47	5.62	0.00*	13.38	3.14	0.00*	1.87
Unemp_CY	-50.84	3.66	-13.90	0.00*	4.90	-10.37	0.00*	1.51
PCI_CY	1.40	0.03	55.33	0.00*	0.07	20.41	0.00*	1.67
Mp35003a_B	37.50	3.18	11.78	0.00*	3.2	11.85	0.00*	1.94
DistInterstate	-0.66	0.02	-40.84	0.00*	0.03	-22.80	0.00*	1.69
DistFreeways	-0.72	0.02	-32.37	0.00*	0.03	-23.15	0.00*	2.11
DistMajorArteries	-0.12	0.09	-1.32	0.19	0.10	-1.21	0.23	1.52
POE_DrivingTime	1297.10	54.42	23.83	0.00*	104.17	12.45	0.00*	2.47
ShopC_DrivingTime	-883.99	55.81	-15.84	0.00*	82.31	-10.74	0.00*	2.41

Observations:	198574	AICc:	5066953
Multiple R-Squared:	0.476	Adjusted R-Squared:	0.476
Joint F-Statistic:	8595	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	143016	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	3197	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	601884996105	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

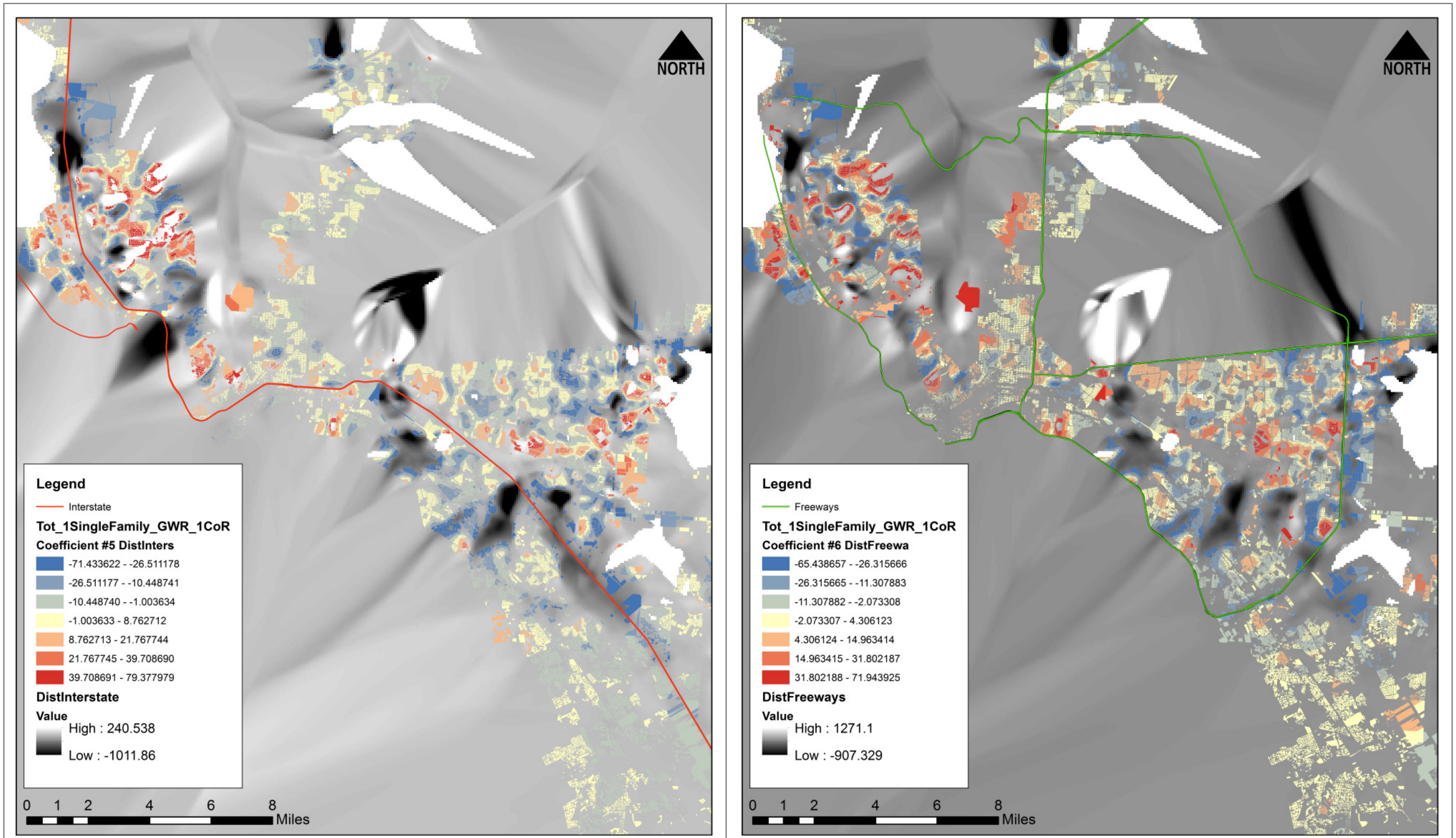
The GWR total value model estimation yields 177,450 observations with invertible matrices, which represent 89.4% from the single-family sample. The GWR summary statistics are shown in Table 4.2 for the mean, minimum, and maximum values. By comparing the mean values of the local coefficients, the signs of *DistInterstate, DistFreeways*, and *POE_DrivingTime* are consistent with the OLS estimates, but GWR coefficients indicate greater magnitudes. However, as shown by Figure 4.1, the impacts transportation infrastructure in *TotValue* are highly sensitive to location. *DistInterstate* indicates that *TotValue* decreases $5.52 per foot according to the mean. *DistInterstate* ranges from a negative $909 per foot to a positive $200 per foot depending on their location, as shown in Figure 4.1(a). Similarly, *DistFreeways* indicates that *TotValue*

decreases $5.98 per foot according to the mean. *DistFreeways* has a range from a negative $596 to a positive $345 per foot, as shown in Figure 4.1(b). *POE_DrivingTime* indicates that *TotValue* increases $2,036 for every additional minute required to drive from a single-family unit to the nearest POE according to the mean. *POE_DrivingTime* ranges from a negative $220,522 to a positive $584,558 per minute, as shown in Figure 4.1(c). Results indicate a higher premium for *DistInterstate*, *DistFreeways,* and *POE_DrivingTime*. Higher premium for *POE_DrivingTime* is observed in parcels more distant to the POEs, in the west and north outskirts of the county, as indicated by the red parcels distant to the POEs.

Table 4.2. Single-family Total Value Model GWR Summary Statistics

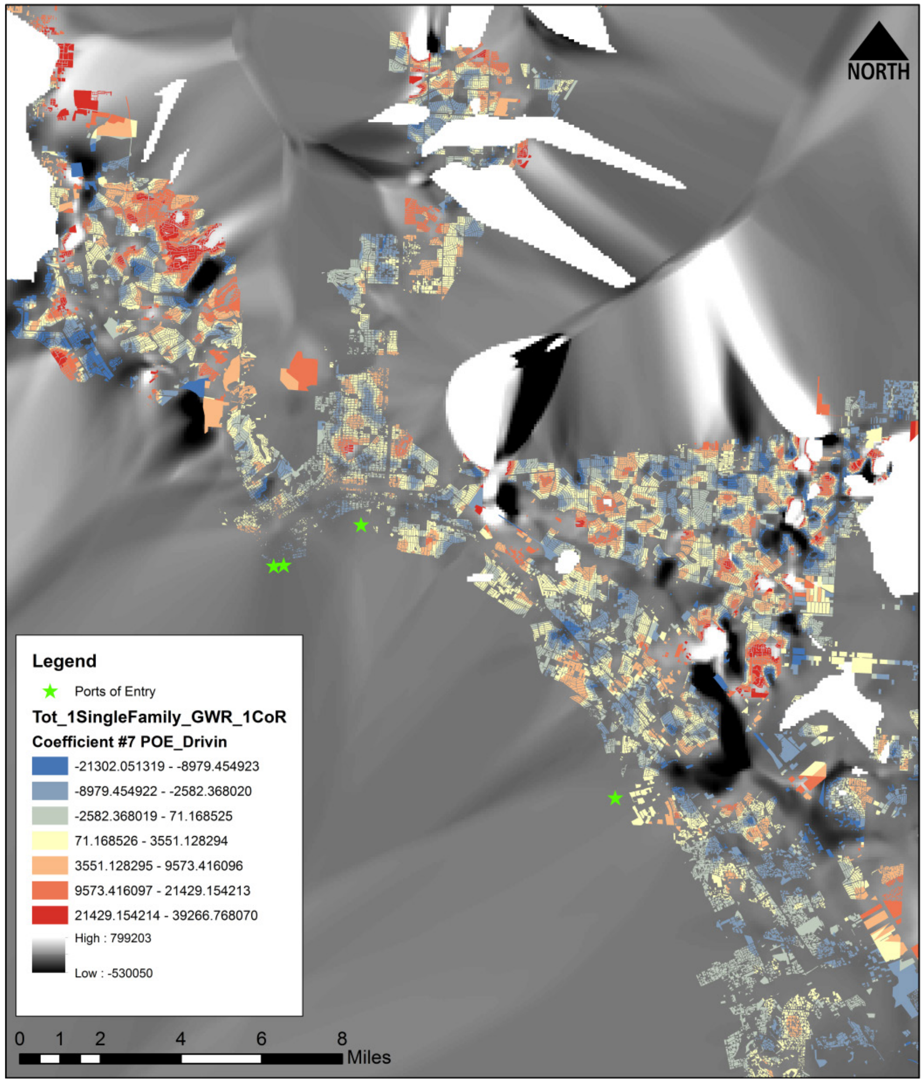
	Local coefficient estimates			Std. Error		
Variable	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
Intercept	-73885	-20119734	29717051	151638	16232	669025
$Bedrooms^2$	955	-17383	8895	512	210	1753
$Baths^2$	5597	-50256	28932	1381	76	4418
Depreciable	2720	-44896	201512	933	91	6181
PCI_CY	0.766	-486	227	1.559	0.110	120
DistInterstate	-5.52	-909	200	6.54	0.248	50.8
DistFreeways	-5.98	-596	345	6.64	0.371	51.8
POE_DrivingTime	2036	-220522	584558	4841	499	18225
Residual Squares: 43854883988		Sigma: 53146.6		R^2: 0.430		
Effective Number: 0.4737		AICc: 396		$AdjR^2$: 0.450		

The GWR global diagnostics show improvement over OLS for the AIC_c from 5,066,953 to 396, but not for the $AdjR^2$ which decreased slightly from 0.476 in OLS to 0.450 in the GWR baseline model. Figure 4.2 illustrates the spatial autocorrelation results using a Getis and Ord's G_i (Hot Spot) test on the standard residuals from the single-family total value model for a) OLS and b) GWR. The G_i** statistic* for each observation in the figure is a Z score. The larger a significant positive Z score, the more intense the clustering of high values (i.e. a hot spot) seen in red. The smaller negative Z scores, the more intense the clustering of low values (i.e. cold spot) in blue. Spatial autocorrelation is confirmed in the residuals from the OLS model with hot spots predominantly in the west and north sides of the county and cold spots in the east, as shown in Figure 4.2(a). Spatial autocorrelation is eliminated in the residuals from GWR, in Figure 4.2(b).



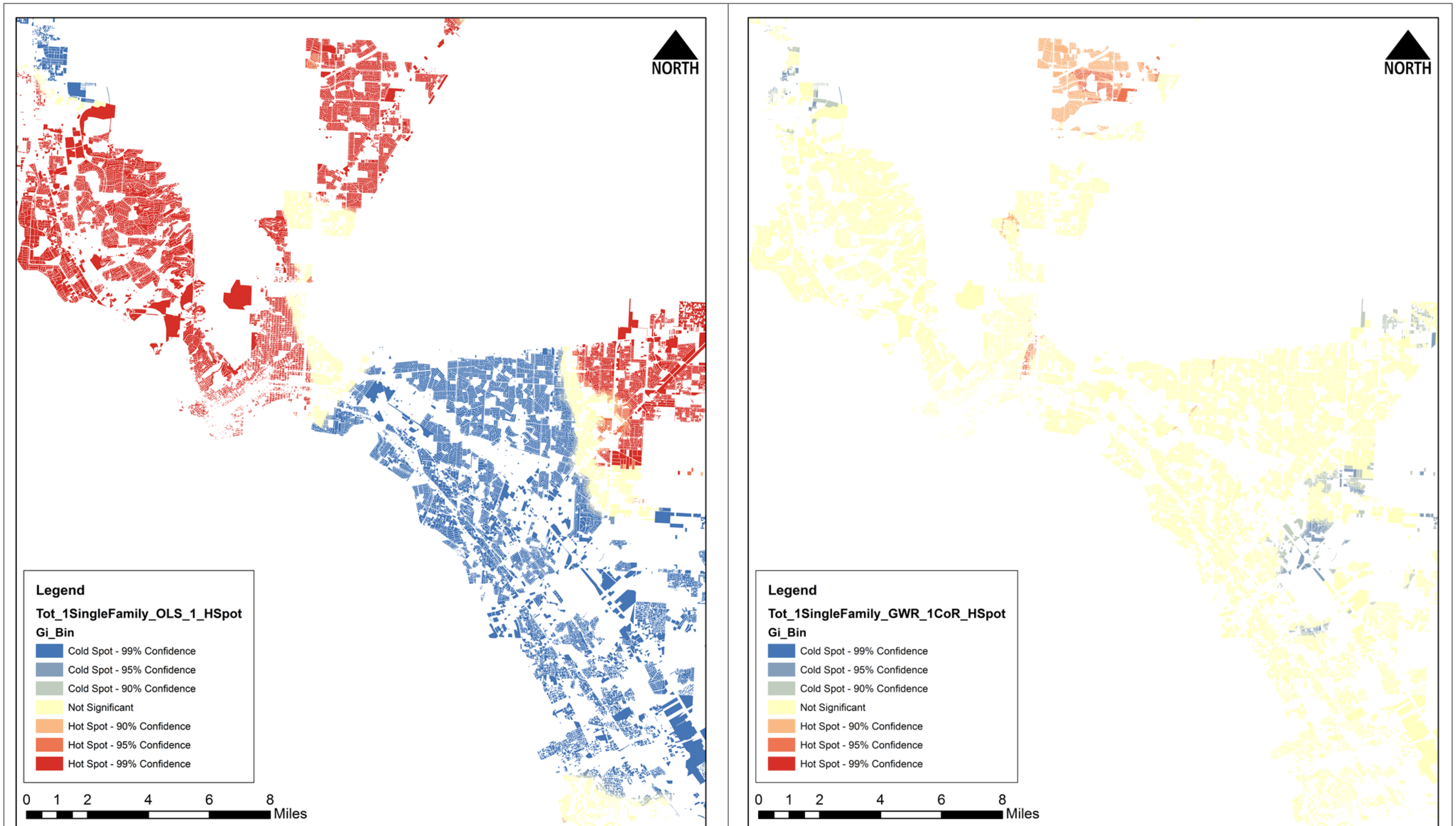
(a) *DistInterstate* (b) *DistFreeways*

Figure 4.1. Single-family Total Value GWR Model Coefficients.



(c) *POE_DrivingTime*

Figure 4.1. Single-family Total Value GWR Model Coefficients (continuation).



a) OLS Getis and Ord's G_i Test Results

b) GWR Getis and Ord's G_i Test Results

Figure 4.2. Single-family Total Value Model Spatial Autocorrelation Test Results.

4.1.2. Single-family Improvement Value Model

The single family sample contains 198,574 data points (56.4% of the total population). The dependent variable is the improvement taxable value (*ImpValue*$_i$). Table 4.3 presents the results for the 20 independent variables plus the intercept term, from which 19 are statistically significant according to their robust 95% confidence interval. Results indicate an increase of $17.30 in *ImpValue* for every additional person in *Mp35003a_B*. *DistInterstate* indicates a decrease of $0.45 per foot in *ImpValue*. Similarly, *DistFreeways* indicate a decrease of $0.49 per foot. *DistMajorArteries* indicates an increase in *ImpValue* of $0.38 for every foot away from the nearest major artery. *POE_DrivingTime* indicates that for every additional minute, *ImpValue* increases $853. *ShopC_DrivingTime* indicates that *ImpValue* increases $449 per driving minute to the nearest shopping center. Adjusted R^2 indicates that this model explains 61.8% of the variation. The significant Jarque-Bera statistic indicates that residuals are not normally distributed. The Koenker BP statistic is significant indicating nonstationarity or heteroskedasticity. The Joint Wald Statistic indicates that the overall model is significant.

Table 4.3. Single-family—Improvement Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	-92069.58	2153.63	-42.75	0.00*	4266.78	-21.58	0.00*	-----
ImpAge	52.20	11.32	4.61	0.00*	19.68	2.65	0.01*	4.80
Air	5798.42	483.96	11.98	0.00*	657.99	8.81	0.00*	2.17
$Baths^2$	1811.24	32.21	56.23	0.00*	221.86	8.16	0.00*	1.29
$Bedrooms^2$	872.03	23.22	37.56	0.00*	107.64	8.10	0.00*	1.52
Garage	2050.83	771.90	2.66	0.01*	665.66	3.08	0.00*	1.25
Depreciable	863.87	19.82	43.58	0.00*	23.14	37.33	0.00*	3.87
LandAcres	481.09	40.04	12.02	0.00*	403.29	1.19	0.23	1.03
ImpSize	30.46	0.08	392.54	0.00*	2.70	11.28	0.00*	1.30
Stories	15338.50	711.01	21.57	0.00*	4531.80	3.38	0.00*	2.10
PopDens_CY	-0.40	0.04	-9.50	0.00*	0.15	-2.73	0.01*	1.40
Renter_CY	4.72	0.88	5.34	0.00*	1.83	2.58	0.01*	1.43
Vacant_CY	7.68	4.82	1.59	0.11	3.72	2.06	0.04	1.86
Unemp_CY	-51.86	2.36	-21.99	0.00*	4.73	-10.97	0.00*	1.50
PCI_CY	1.17	0.02	71.60	0.00*	0.08	14.65	0.00*	1.67
Mp35003a_B	17.26	2.05	8.40	0.00*	2.11	8.18	0.00*	1.93
DistInterstate	-0.45	0.01	-43.37	0.00*	0.03	-15.40	0.00*	1.69
DistFreeways	-0.49	0.01	-34.26	0.00*	0.02	-24.19	0.00*	2.11
DistMajorArteries	0.38	0.06	6.55	0.00*	0.05	8.37	0.00*	1.51
POE_DrivingTime	853.54	35.10	24.32	0.00*	72.48	11.78	0.00*	2.47

ShopC_DrivingTime	-449.25	35.99	-12.48	0.00*	50.20	-8.95	0.00*	2.41

Observations:	198574	AICc:	4892903
Multiple R-Squared:	0.618	Adjusted R-Squared:	0.618
Joint F-Statistic:	16089	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	265239	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	161	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	938416747444	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

The GWR improvement value model has 177,450 regression points with invertible matrices, which represent 87.6% from the single-family sample. Table 4.4 presents the GWR summary statistics. The mean values of the local coefficients for *DistInterstate* and *DistFreeways* show greater magnitudes and positive signs, departures from their OLS counterparts. *DistMajorArteries* shows a negative sign contrary to its OLS estimation. *POE_DrivingTime* is positive, consistent with OLS, but the GWR mean coefficient indicates a smaller magnitude. Figure 4.3 shows the transportation infrastructure impacts in *ImpValue* according to location. *DistInterstate* indicates that *ImpValue* increases $1.25 per foot according to the mean. Local coefficients for *DistInterstate* range from a negative $343 to a positive $241 per foot depending on their location, as shown in Figure 4.3(a). *DistFreeways* indicates that *ImpValue* increases $1.29 per foot according to the mean. *DistFreeways* ranges from a negative $218 to a positive $341, as shown in Figure 4.3(b). *DistMajorArteries* indicates that *ImpValue* decreases $0.16 per foot according to the mean. Local coefficients for *DistMajorArteries* range from a negative $548 to a positive $116 per foot, as shown in Figure 4.3(c). *POE_DrivingTime* indicates that *ImpValue* increases $347 per minute according to the mean. Local coefficients for *POE_DrivingTime* range from a negative $128,320 to a positive $418,682 per minute, as shown in Figure 4.3(d).

Table 4.4. Single-family—Improvement Value Model GWR Summary Statistics

	Local coefficient estimates			Std. Error		
Variable	Mean	Min	Max	Mean	Min	Max
Intercept	-94120	-13444676	6680229	47716	5338	194500
Bedrooms^2	409	-4525	4950	150	63.5	417
Depreciable	1064	-9004	163198	280	28.9	1893
ImpSize	33.8	-190	74.2	1.03	0.027	2.51
DistInterstate	1.25	-343	241	2.30	0.120	28.2
DistFreeways	1.29	-218	341	2.27	0.114	46.6
DistMajorArteries	-0.163	-548	116	2.12	0.268	46.2

POE_DrivingTime	347	-128320	418682	1516	152	5253
Residual Squares: 30651063734		Sigma: 15945		R^2: 0.954		
Effective Number: 4.44		AICc: 2778		AdjR^2: 0.953		

The GWR global diagnostics improve from OLS for the AIC_c from 4,892,903 to 2,778 respectively, and for the AdjR^2 which increased from 0.618 in OLS to 0.953 in the GWR baseline model. Figure 4.4 illustrates the spatial autocorrelation test results on the standard residuals from the single-family improvement value model for a) OLS and b) GWR. Results indicate that spatial autocorrelation is a problem in the residuals from the OLS model with hot spots indicating intense clustering of high values predominantly in the west and north and cold spots in the east side of the county, as seen in Figure 4.4(a). Spatial autocorrelation is not present among the GWR residuals in Figure 4.4(b).

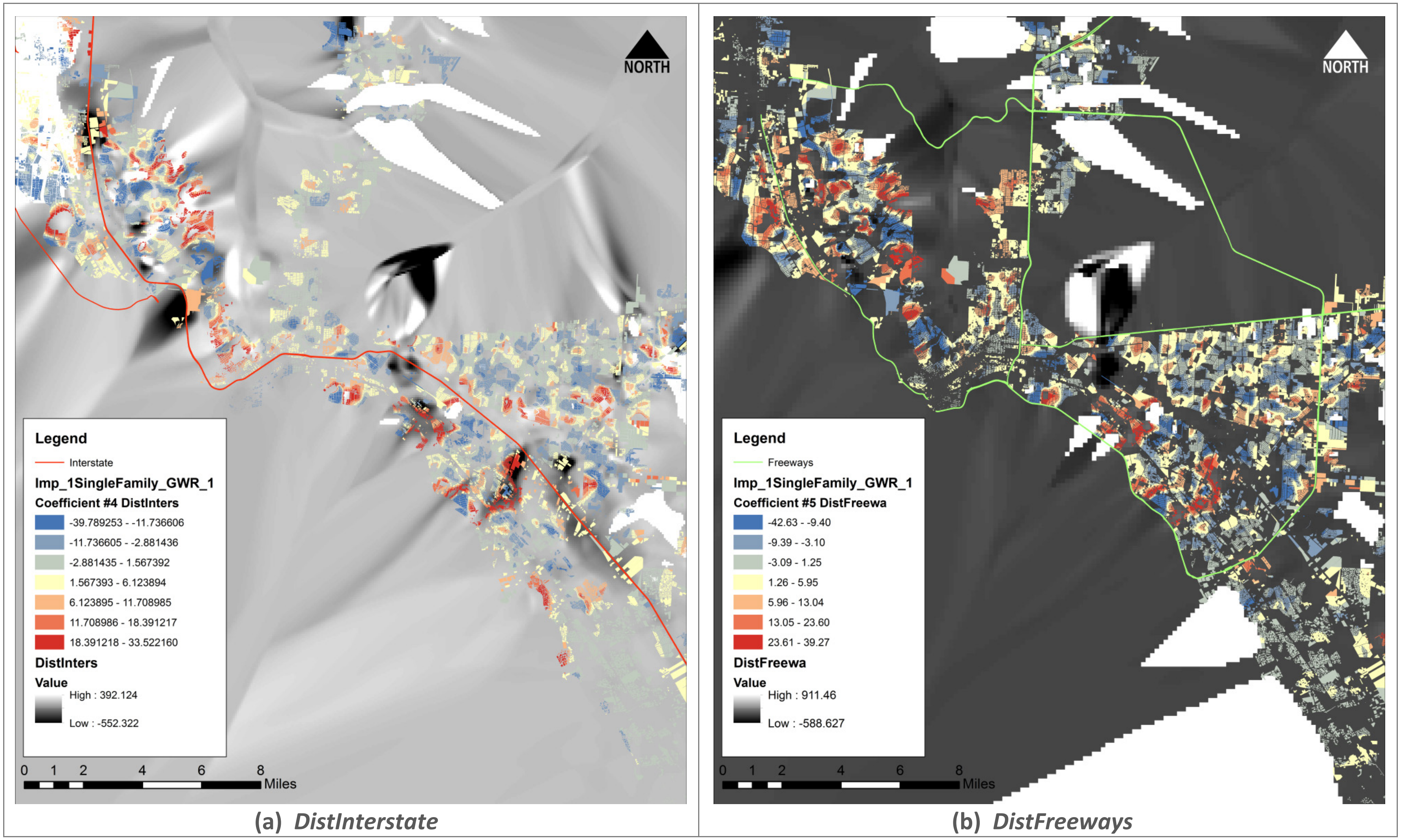
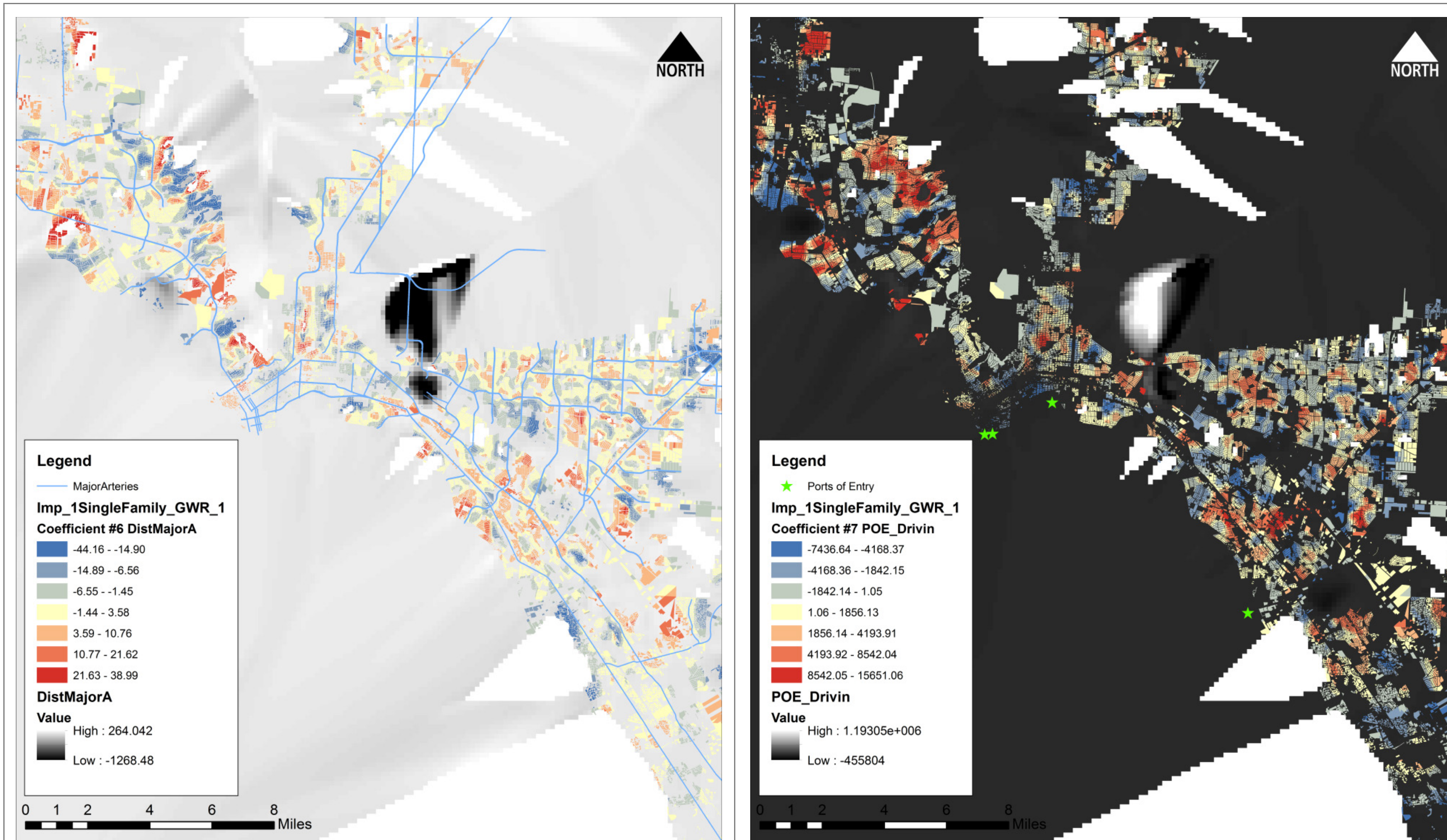


Figure 4.3. Single-family Improvement Value GWR Model Coefficients.



(c) *DistMajorArteries* (d) *POE_DrivingTime*

Figure 4.3. Single-family Improvement Value GWR Model Coefficients (continuation).

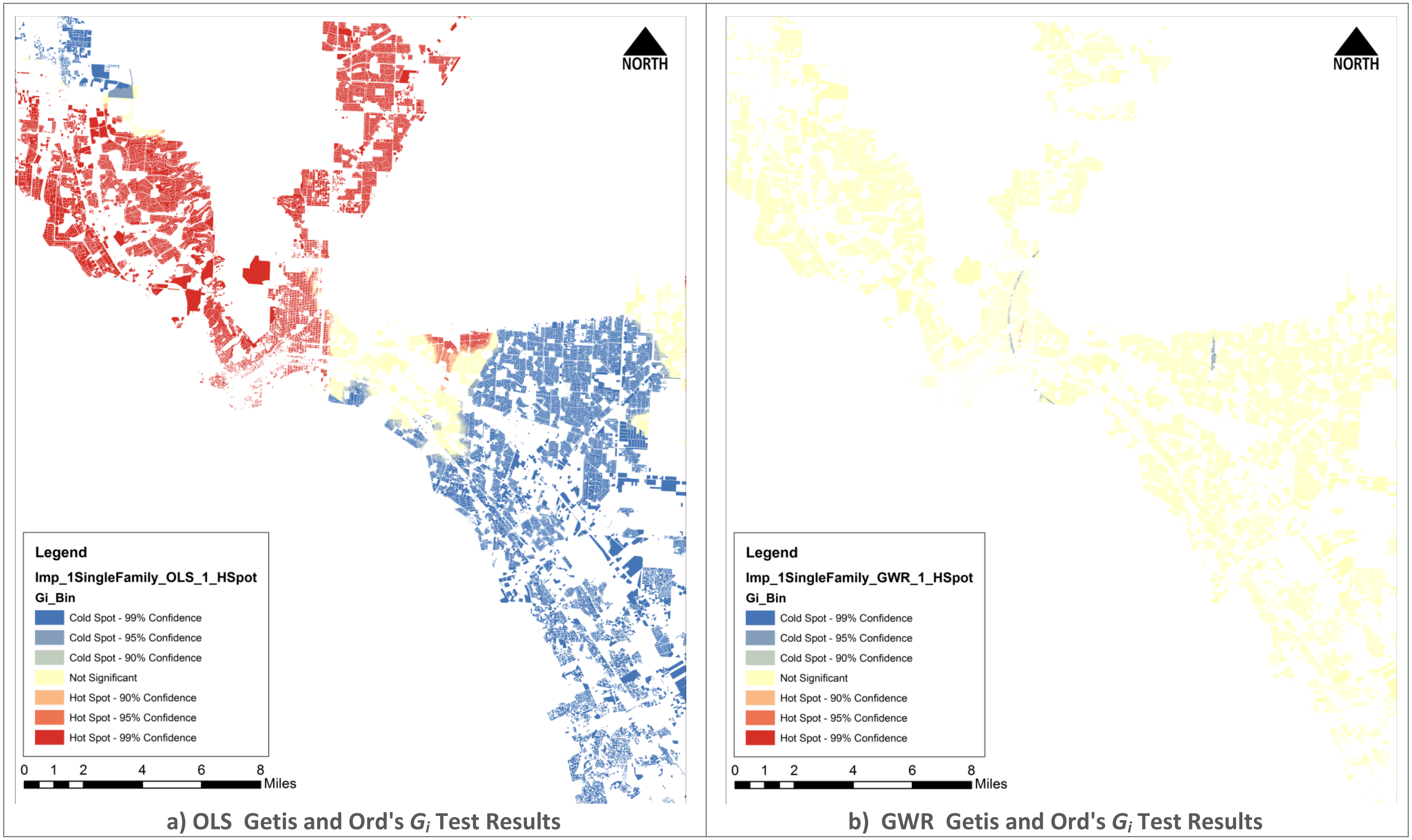


Figure 4.4. Single-family Improvement Value Model Spatial Autocorrelation Test Results.

4.1.3. Single-family Land Value Model

The land value sample contains 198,574 data points (56.4% of the total population). The dependent variable is land taxable value ($LandValue_i$) for single-family units. Table 4.5 presents the results for the 6 independent variables plus the intercept term. All of the coefficients are statistically significant. *DistInterstate* indicates an increase in *LandValue* of $0.29 per foot, *DistFreeways* an increase of $0.40 per foot, and *DistMajorArteries* an increase of $0.53 for every foot a parcel is located away from a transportation facility. *POE_DrivingTime* indicates that *LandValue* increases $1,276 for every minute required to drive from a parcel to a POE, which implies that as distance to a POE increases, the *LandValue* of single-family parcels increases. Similarly, as *ShopC_DrivingTime* increases, *LandValue* is $186 higher per minute. Adjusted R^2 indicates that the land value model explains 12.6% of the variation. The residuals are not normally distributed. Nonstationarity and heteroskedasticity are confirmed by a significant Koenker BP statistic. A Joint Wald Statistic indicates that the overall model is significant.

Table 4.5. Single-family—Land Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	10755.56	470.30	22.86	0.00*	763.71	14.08	0.00*	----
LandAcres	7058.33	43.70	161.50	0.00*	1852.62	3.81	0.00*	1.01
DistInterstate	0.29	0.01	26.54	0.00*	0.02	15.21	0.00*	1.54
DistFreeways	0.40	0.02	26.12	0.00*	0.02	17.19	0.00*	2.00
DistMajorArteries	0.53	0.06	8.56	0.00*	0.10	5.29	0.00*	1.39
POE_DrivingTime	1276.23	33.43	38.17	0.00*	61.34	20.81	0.00*	1.85
ShopC_DrivingTime	186.17	36.86	5.05	0.00*	73.26	2.54	0.01*	2.08

Observations:	198574	AICc:	4931181
Multiple R-Squared:	0.125	Adjusted R-Squared:	0.125
Joint F-Statistic:	4765	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	2164	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	17576	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	182241193886	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

The GWR land value model has 173,916 regression points with invertible matrices, which represent 87.6% from the single-family sample. Table 4.6 reports GWR summary statistics from the land value model. The mean local coefficients exhibit signs opposite to their OLS counterparts

except for *DistFreeways*, which has a positive sign consistent with OLS. As shown by Figure 4.5, a higher premia for *DistInterstate*, *DistFreeways, and POE_DrivingTime* is predominant in the west side. As *DistInterstate* increases, *LandValue* decreases $0.98 per foot according to the mean. Local coefficients for *DistInterstate* range from a negative $467 to a positive $526 per foot depending on their location, as shown in Figure 4.5(a). As *DistFreeways* increases, *LandValue* increases $0.59 per foot according to the mean. *DistFreeways* ranges from a negative $133 to a positive $532 per foot depending on their location, as shown in Figure 4.5(b). As *DistMajorArteries* increases, *LandValue* decreases $0.82 per foot according to the mean. *DistMajorArteries* ranges from a negative $320 to a positive $153 per foot depending on their location, as shown in Figure 4.5(c). *POE_DrivingTime* indicates that for every additional driving minute to the nearest POE, the *LandValue* decreases almost $50 on average. The sign of *POE_DrivingTime* is in line with the findings in Fullerton and Villalobos (2011); furthermore, it indicates that the premia is capitalized primarily by the land instead of the improvement. Coefficients from *POE_DrivingTime* range from a negative $144,729 to a positive $222,070 per minute depending on their location, as shown in Figure 4.5(d). *ShopC_DrivingTime* indicates that *LandValue* decreases $96 per minute according to the mean. Local coefficients for *ShopC_DrivingTime* range from a negative $155,053 to a positive $216,636 per minute, as shown in Figure 4.5(e).

Table 4.6. Single-family—Land Value Model GWR Summary Statistics

	Local coefficient estimates			Std. Error		
Variable	Mean	Min	Max	Mean	Min	Max
Intercept	25590	-3026402	6293759	263956	28948	1457861
LandAcres	60894	-759530	471447	45477	153	356998
DistInterstate	-0.978	-467	526	15.7	0.809	180
DistFreeways	0.592	-133	532	15.2	0.710	335
DistMajorArteries	-0.824	-320	153	14.3	1.77	330
POE_DrivingTime	-49.9	-144729	222070	11297	1092	42199
ShopC_DrivingTime	-96.3	-155053	216636	10233	1459	77574
Residual Squares:	490882289661	Sigma:	104479	R^2:	0.839	
Effective Number:	2.03	AICc:	1223	AdjR^2:	0.836	

The GWR global diagnostics show improvement over their OLS counterpart for the AIC_c from 4,931,181 to 1,223 respectively, and for the $AdjR^2$ from 0.125 in OLS to 0.836 in the GWR baseline model. Figure 4.6 illustrates the spatial autocorrelation test on the standard residuals from the single-family land value model for a) OLS and b) GWR. Results indicate that spatial autocorrelation is a problem for the OLS residuals with hot spots predominantly on the west side and also on the east side, indicating intense clustering of high values. Cold spots dominate the central part of the county and the outer east, as shown in blue in Figure 4.6(a). Spatial autocorrelation almost disappears from the GWR residuals, as shown in light yellow in Figure 4.6(b).

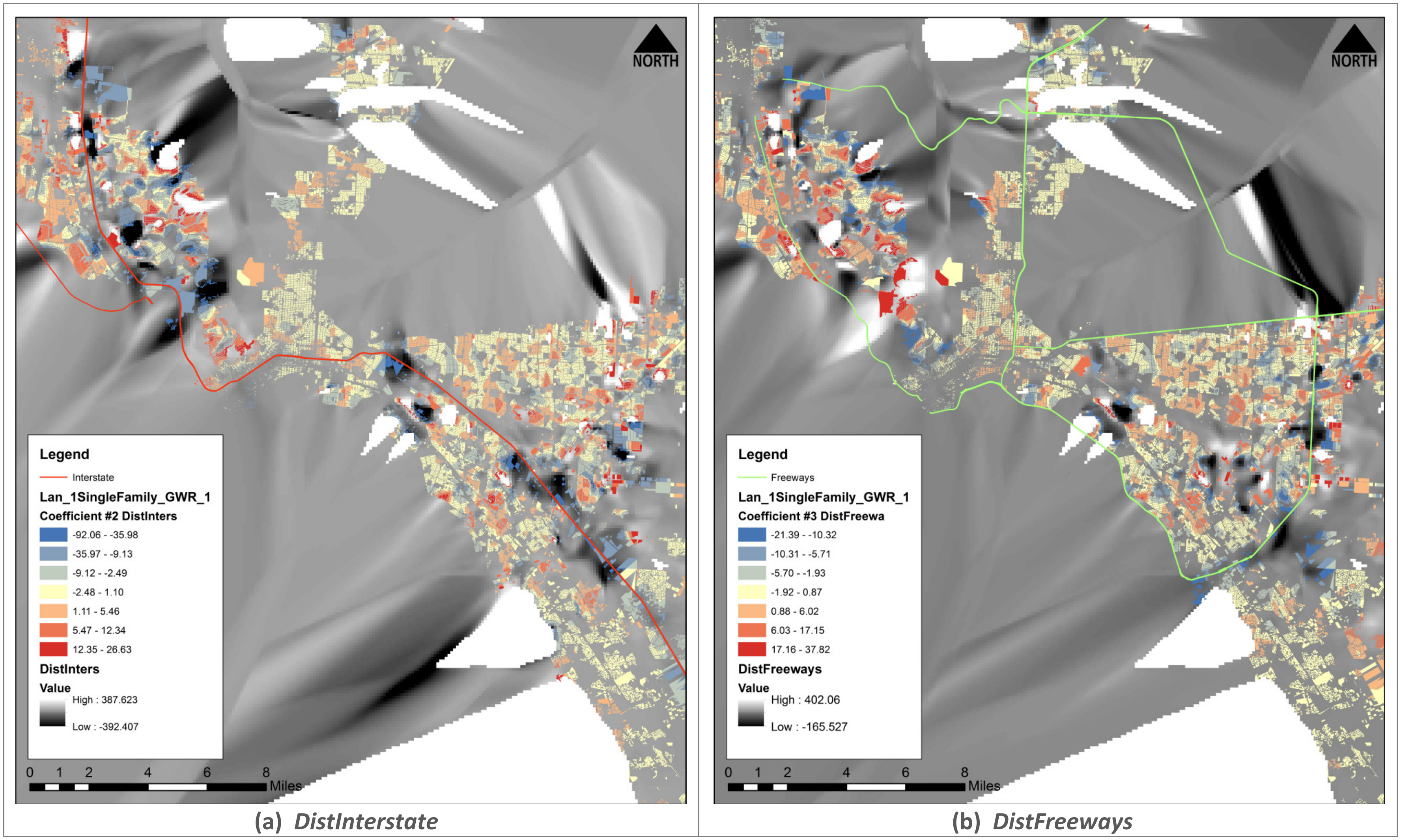
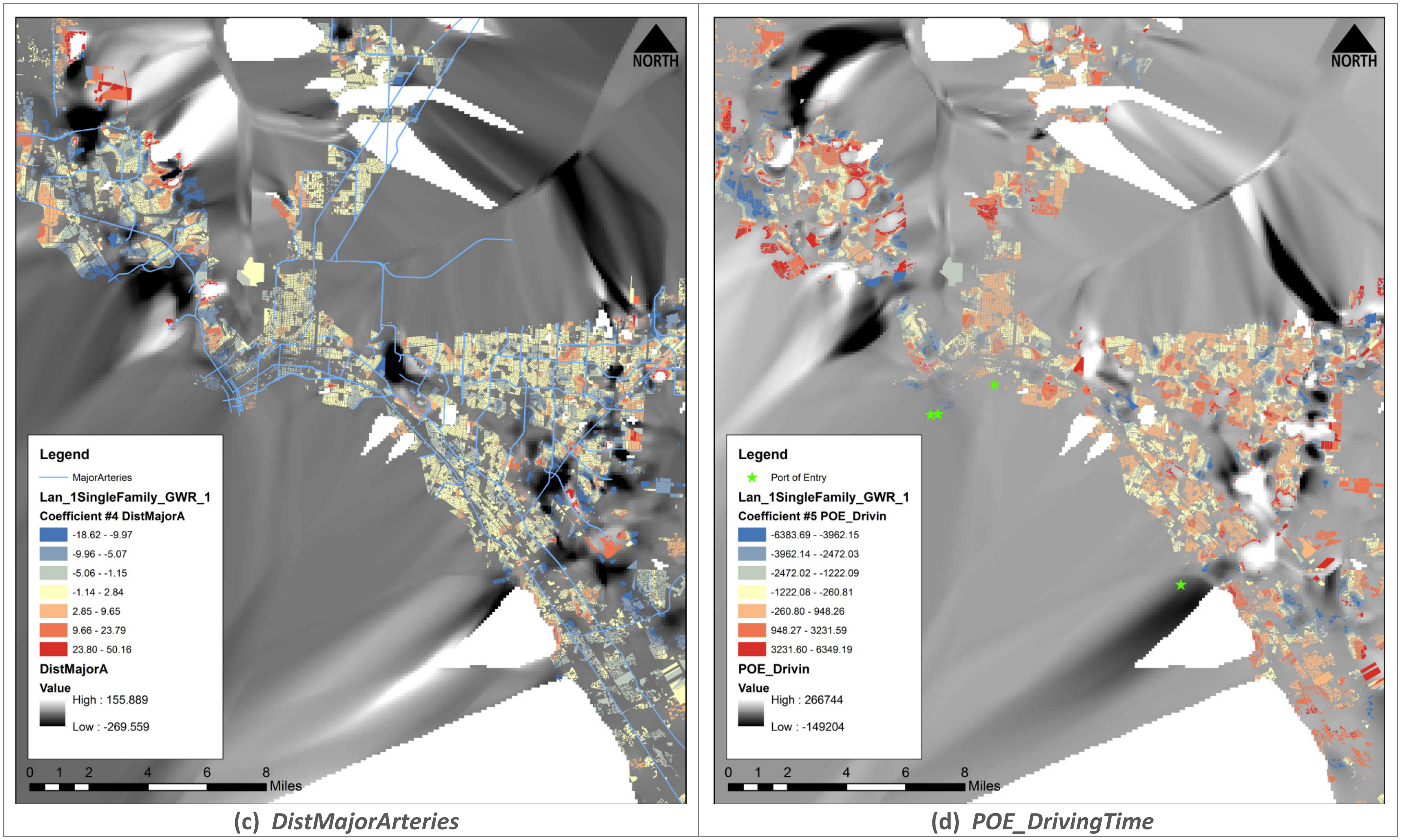
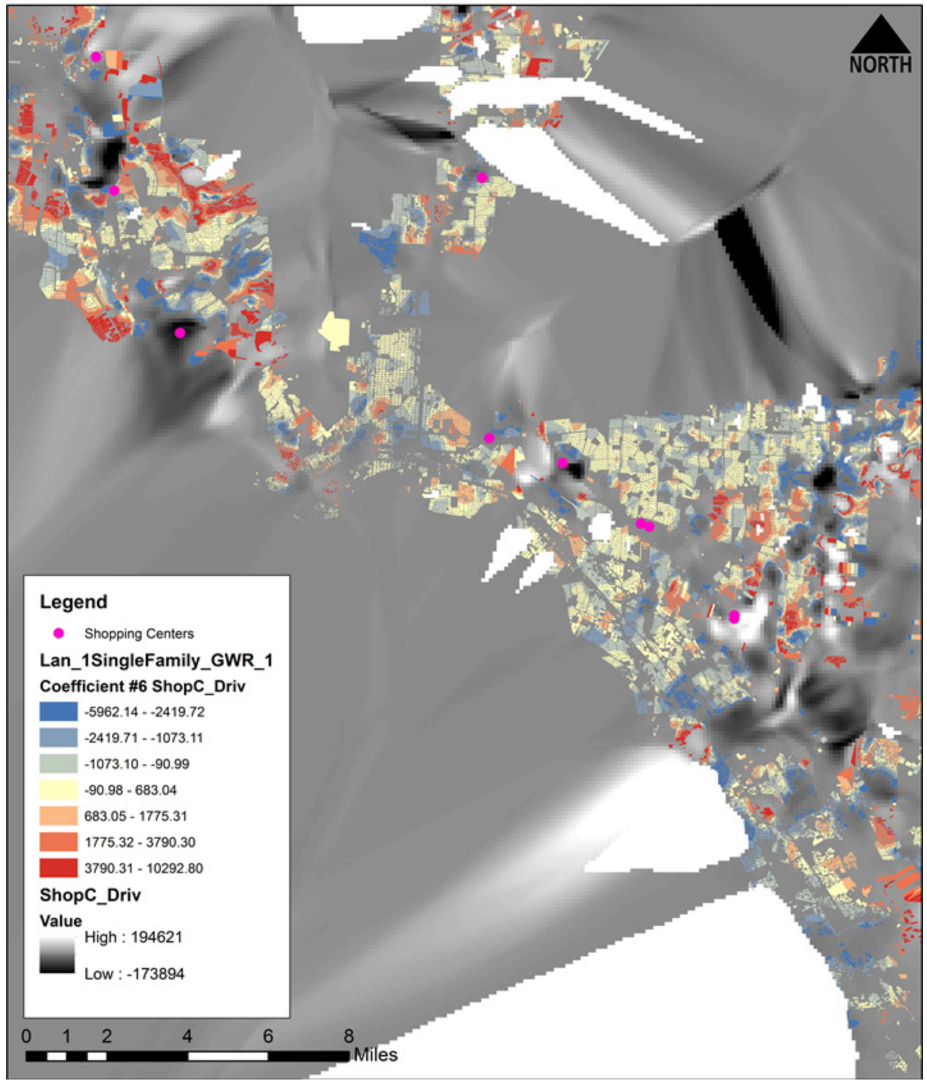


Figure 4.5. Single-family Land Value GWR Model Coefficients.



(c) *DistMajorArteries* (d) *POE_DrivingTime*

Figure 4.5. Single-family Land Value GWR Model Coefficients (continuation).



(e) *ShopC_DrivingTime*

Figure 4.5. Single-family Land Value GWR Model Coefficients (continuation).

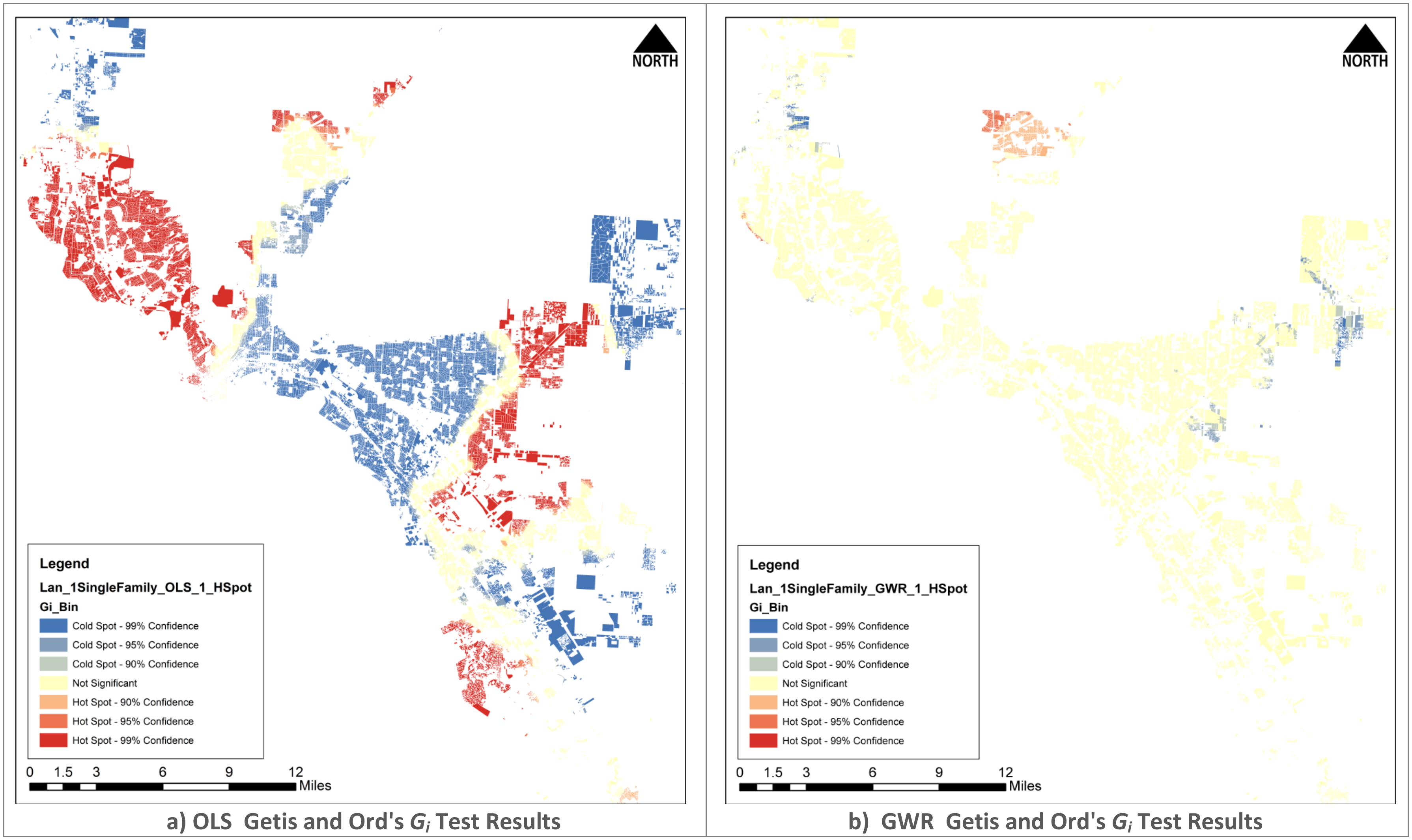


Figure 4.6. Single-family Land Value Model Spatial Autocorrelation Test Results.

4.2. MULTI-FAMILY

4.2.1. Multi-family Total Value Model

The total value multi-family sample contains 8,373 observations (2.4% of the total population) where the dependent variable is *TotValue*$_i$. Table 4.7 presents the results for the 21 independent variables plus the intercept term, for which 8 coefficients are statistically significant according to their robust 95% confidence interval. *Mp35003a_B* is not significant for multi-family units. *DistInterstate* indicates that *TotValue* decreases $2.52 per foot. *DistFreeways* indicate a similar decrease in *TotValue* of $3.11 per foot. *DistMajorArteries* indicates a decrease in *TotValue* of $15.10 for every additional foot a multi-family unit is located away from the nearest major artery. On the other hand, *POE_DrivingTime* indicates that *TotValue* increases $5,011 for every driving minute a multi-family property is located away from the nearest POE. *ShopC_DrivingTime* is also not significant for multi-family units. Adjusted R^2 indicates that the total value model explains 85.1% of the variation. The significant Jarque-Bera statistic indicates that residuals are not normal. The Koenker BP statistic is significant suggesting nonstationarity or heteroskedasticity in the model. The Joint Wald Statistic indicates that the overall model is significant.

Table 4.7. Multi-family—Total Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	-223637.44	67163.09	-3.33	0.00*	228629.88	-0.98	0.33	-----
ImpAge	907.85	381.80	2.38	0.02*	349.97	2.59	0.01*	3.26
Air	-47340.13	16349.11	-2.90	0.00*	45444.34	-1.04	0.30	1.13
$Baths^2$	684.09	1144.43	0.60	0.55	1132.84	0.60	0.55	1.36
$Bedrooms^2$	535.29	782.12	0.68	0.49	318.23	1.68	0.09	1.40
Garage	2988.55	47504.38	0.06	0.95	25522.12	0.12	0.91	1.02
Depreciable	1404.20	496.83	2.83	0.00*	691.66	2.03	0.04*	2.75
LandAcres	102804.88	5982.37	17.18	0.00*	80585.93	1.28	0.20	3.88
ImpSize	15.32	0.16	93.96	0.00*	2.86	5.35	0.00*	3.98
Stories	44819.01	31855.46	1.41	0.16	202721.25	0.22	0.83	1.10
Vacant	54843.78	262014.53	0.21	0.83	136922.79	0.40	0.69	1.02
PopDens_CY	0.85	1.53	0.55	0.58	1.65	0.51	0.61	1.27
Renter_CY	-58.18	29.71	-1.96	0.05	65.10	-0.89	0.37	2.11
Vacant_CY	1188.61	261.04	4.55	0.00*	645.95	1.84	0.07	2.15
Unemp_CY	134.23	140.60	0.95	0.34	200.56	0.67	0.50	1.68
PCI_CY	3.08	0.67	4.62	0.00*	0.76	4.04	0.00*	1.51
Mp35003a_B	3.88	164.00	0.02	0.98	227.23	0.02	0.99	2.19

DistInterstate	-2.52	0.57	-4.40	0.00*	0.84	-3.00	0.00*	1.76
DistFreeways	-3.11	0.88	-3.53	0.00*	0.99	-3.13	0.00*	1.82
DistMajorArteries	-15.09	4.96	-3.04	0.00*	6.97	-2.16	0.03*	1.33
POE_DrivingTime	5011.87	1586.11	3.16	0.00*	1826.75	2.74	0.01*	2.63
ShopC_DrivingTime	1950.02	1714.39	1.14	0.26	3018.47	0.65	0.52	1.40

Observations:	8373	AICc:	241777
Multiple R-Squared:	0.852	Adjusted R-Squared:	0.851
Joint F-Statistic:	2282	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	1859	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	3394	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	57802301	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

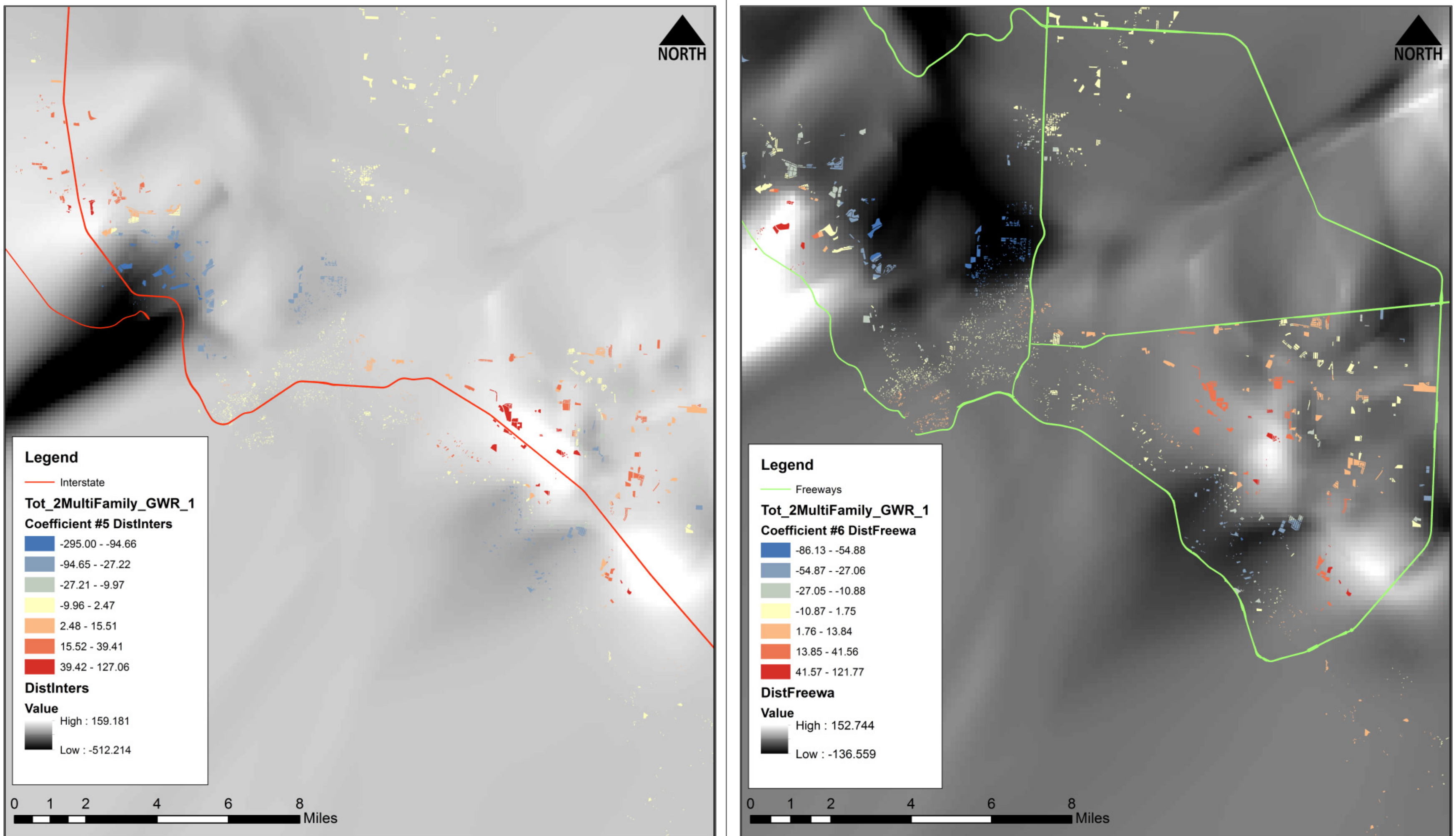
The GWR total value results contain 8,373 regression points with invertible matrices, which represent 100% from the multi-family sample (see Table 4.8). By comparing mean values, the signs of all coefficients are consistent with the OLS estimates, and the respective magnitudes are very close in value. Figure 4.7 illustrates the spatial variation of the transportation infrastructure impacts in *TotValue* of multi-family properties. *DistInterstate* indicates that *TotValue* decreases $2.29 per foot according to the mean. Local coefficients for *DistInterstate* range from a negative $295 to a positive $127 per foot depending on their location, as shown in Figure 4.7(a). *DistFreeways* indicates that *TotValue* decreases $7.40 per foot according to the mean. Local coefficients for *DistFreeways* range from a negative $86 to a positive $121 per foot, as shown in Figure 4.7(b). *DistMajorArteries* indicates that *TotValue* decreases $16.80 per foot according to the mean. Local coefficients of *DistMajorArteries* range from a negative $351 to a positive $67.60 per foot depending on location, as shown in Figure 4.7(c). *POE_DrivingTime* indicates that *TotValue* increases $6,300 for every minute required to drive from a multi-family unit to the nearest POE according to the mean. *POE_DrivingTime* ranges from a negative $139,069 per minute to an increase in *TotValue* of $184,846 per minute, as shown in Figure 4.7(d).

Table 4.8. Multi-family—Total Value Model GWR Summary Statistics

	Local coefficient estimates			Std. Error		
Variable	Mean	Min	Max	Mean	Min	Max
Intercept	-523278	-12464340	3608559	173207	38280	1151359
ImpAge	3489	-21557	71511	1010	231	5903
Depreciable	4912	-32493	114948	1314	355	11315
ImpSize	18.5	9.99	28.0	0.268	0.043	2.387
PCI_CY	3.69	-12.2	43.4	1.46	0.673	6.285

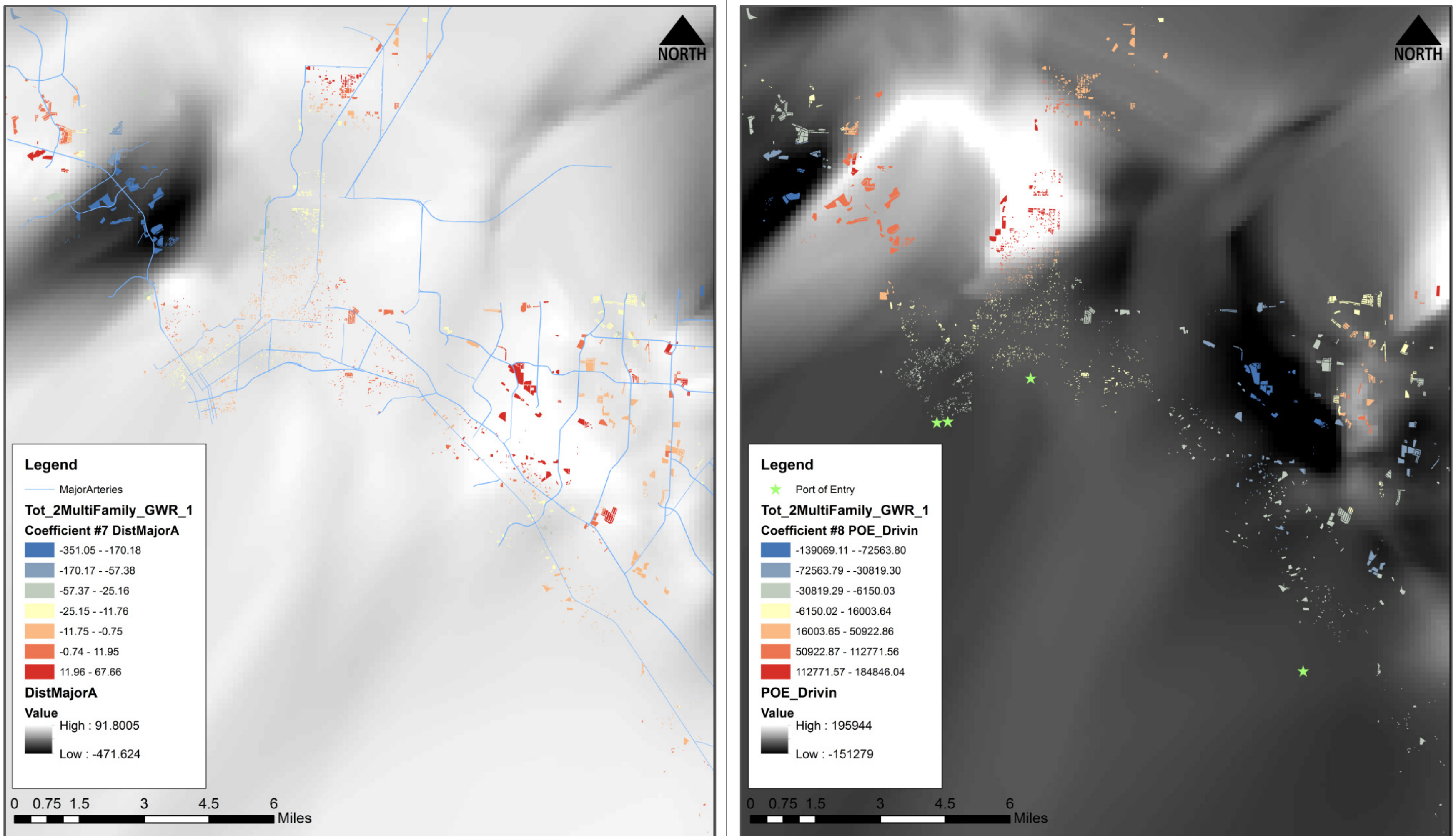
DistInterstate	-2.29	-295	127	5.71	1.24	14.2
DistFreeways	-7.40	-86.1	121	5.54	1.12	13.7
DistMajorArteries	-16.8	-351	67.6	9.57	3.50	17.1
POE_DrivingTime	6300	-139069	184846	8609	2652	22446
Residual Squares: 13055952613780 Effective Number: 17.3		Sigma: 137886 AICc: 18672		R^2: 0.774 AdjR^2: 0.768		

The GWR global diagnostics show improvement over OLS for the AIC_c from 241,777 to 18,672 respectively; however, AdjR^2 declined slightly from 0.851 in OLS to 0.768 in the GWR baseline model. Figure 4.8 illustrates the spatial autocorrelation test results for the standard residuals from the multi-family total value model for a) OLS and b) GWR. Results indicate that spatial autocorrelation is a problem for the OLS residuals with cold spots predominantly on the west side and also on the east side, indicating intense clustering of low values in blue. Spatial autocorrelation is practically absent from the GWR residuals, as shown in Figure 4.8(b).



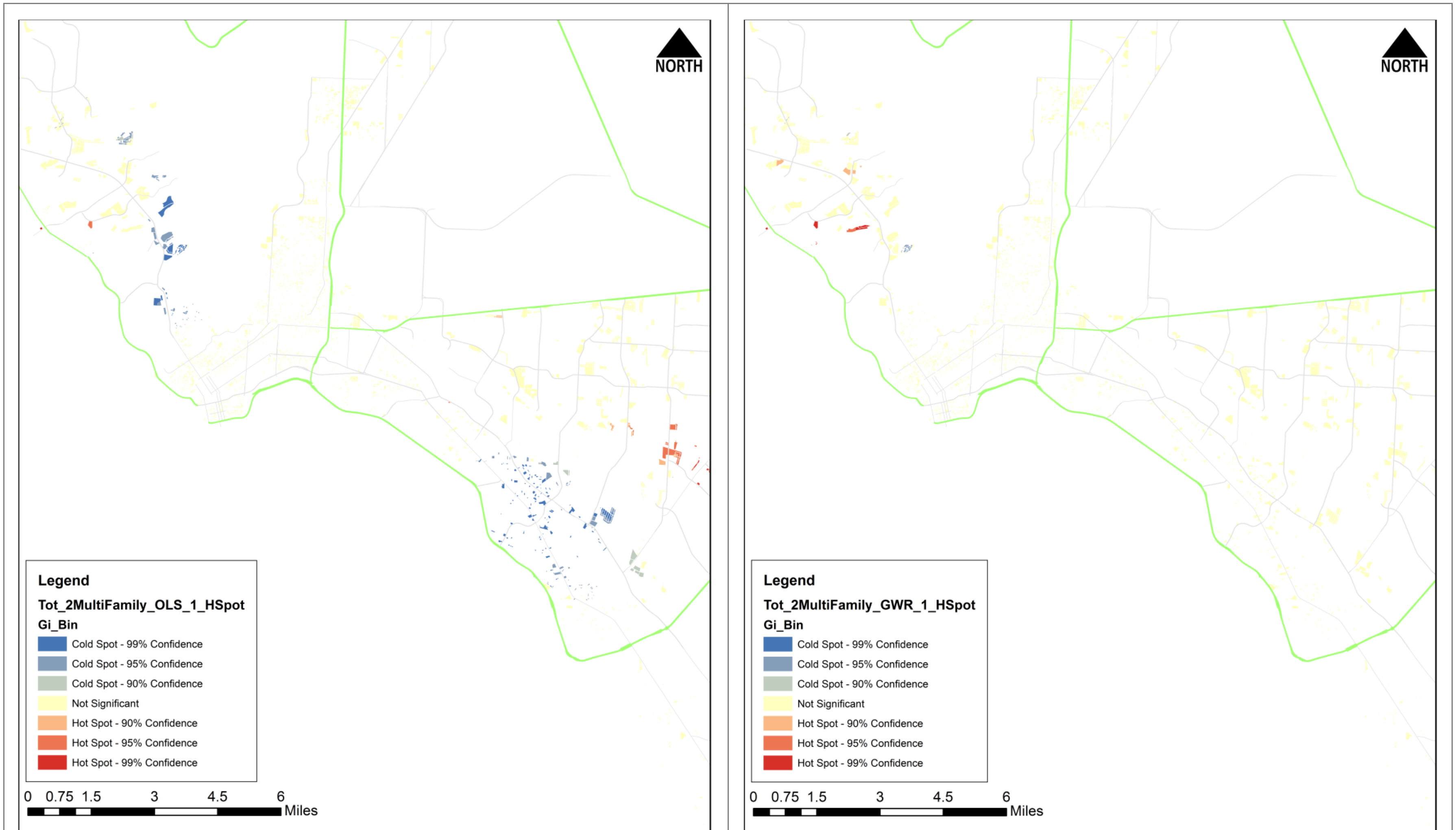
(a) *DistInterstate* (b) *DistFreeways*

Figure 4.7. Multi-family Total Value GWR Model Coefficients.



(c) *DistMajorArteries* (d) *POE_DrivingTime*

Figure 4.7. Multi-family Total Value GWR Model Coefficients (continuation).



a) OLS Getis and Ord's G_i Test Results

b) GWR Getis and Ord's G_i Test Results

Figure 4.8. Multi-family Total Value Model Spatial Autocorrelation Test Results.

4.2.2. Multi-family Improvement Value Model

The improvement value sample has 8,373 data points (2.4% of the total population). The dependent variable is $ImpValue_i$ for multi-family units. Table 4.9 summarizes the results for the 20 independent variables plus the intercept term, from which 8 parameters are significant at the 5% level. The *Mp35003a_B* coefficient is not significant. *ImpValue* decreases $2.09 for every foot *DistInterstate* increases. *DistFreeways* indicates a similar decrease of $2.44 per foot. *DistMajorArteries* exhibits a decrease of $13.78 in *ImpValue* for every foot away from the nearest major artery. *POE_DrivingTime* indicates that an increase in *ImpValue* of $3,803 for every additional minute driving to the nearest POE. The *ShopC_DrivingTime* parameter is not significant. Adjusted R^2 indicates that the improvement value model explains 82.8% of the variation in the dependent variable. The residuals are not normal. Nonstationarity and heteroskedasticity are confirmed. The overall model is significant as shown by the Joint Wald statistic.

Table 4.9. Multi-family—Improvement Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	-228471.19	62743.79	-3.64	0.00*	214687.93	-1.06	0.29	-----
ImpAge	768.05	356.99	2.15	0.03*	320.10	2.40	0.02*	3.25
Air	-34483.75	15279.67	-2.26	0.02*	42799.36	-0.81	0.42	1.13
$Baths^2$	659.17	1070.28	0.62	0.54	1012.89	0.65	0.52	1.36
$Bedrooms^2$	381.27	731.37	0.52	0.60	300.34	1.27	0.20	1.40
Garage	1216.86	44426.68	0.03	0.98	23308.42	0.05	0.96	1.02
Depreciable	1551.21	464.60	3.34	0.00*	642.75	2.41	0.02*	2.75
LandAcres	62145.09	5594.90	11.11	0.00*	69279.48	0.90	0.37	3.88
ImpSize	13.76	0.15	90.19	0.00*	2.52	5.45	0.00*	3.98
Stories	51556.85	29691.07	1.74	0.08	191527.14	0.27	0.79	1.10
PopDens_CY	0.85	1.43	0.59	0.55	1.54	0.55	0.58	1.27
Renter_CY	-62.92	27.79	-2.26	0.02*	63.06	-1.00	0.32	2.11
Vacant_CY	1133.70	244.08	4.64	0.00*	632.61	1.79	0.07	2.15
Unemp_CY	155.19	131.44	1.18	0.24	187.22	0.83	0.41	1.68
PCI_CY	2.54	0.62	4.06	0.00*	0.71	3.56	0.00*	1.51
Mp35003a_B	-21.93	153.37	-0.14	0.89	210.10	-0.10	0.92	2.18
DistInterstate	-2.09	0.53	-3.90	0.00*	0.81	-2.58	0.01*	1.76
DistFreeways	-2.44	0.82	-2.96	0.00*	0.93	-2.62	0.01*	1.82
DistMajorArteries	-13.78	4.64	-2.97	0.00*	6.61	-2.08	0.04*	1.33
POE_DrivingTime	3803.88	1483.05	2.56	0.01*	1704.55	2.23	0.03*	2.63
ShopC_DrivingTime	1802.30	1601.07	1.13	0.26	1983.60	0.60	0.55	1.39

Observations: 8373 — AICc: 240655

Multiple R-Squared: 0.828 — Adjusted R-Squared: 0.828

Joint F-Statistic:	2010	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	1456	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	3212	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	62265564	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

The GWR improvement value model estimation yields 8,373 regression points with invertible Hessians, which represent 100% from the multi-family sample (see Table 4.10). All mean local coefficients have signs consistent with their OLS counterparts. As shown by Figure 4.9, the spatial variation of the transportation accessibility impacts on *ImpValue* is similar to the variation observed for *TotValue*. A higher premia is observed for *DistInterstate*, *DistFreeways,* and *DistMajorArteries* in properties towards the east side of the county as shown by parcels in orange and red. *DistInterstate* indicates that *ImpValue* decreases $2.18 per foot according to the mean. *DistInterstate* ranges from a negative $259 per foot to a positive $98 per foot depending on their location, as shown in Figure 4.9(a). *DistFreeways* indicates that *ImpValue* decreases $7.68 per foot according to the mean. Local coefficients of *DistFreeways* range from a negative $83.80 to a positive $106 per foot, as shown in Figure 4.9(b). *DistMajorArteries* indicates that *ImpValue* decreases $16.00 per foot according to the mean. *DistMajorArteries* ranges from a negative $359 to a positive $67.90 per foot, as shown in Figure 4.9(c). *POE_DrivingTime* indicates that *ImpValue* increases $7,062 per minute according to the mean. Local coefficients of *POE_DrivingTime* range from a negative $119,238 per minute to a positive $175,832 per minute, as shown in Figure 4.9(d). *POE_DrivingTime* shows positive coefficients for properties on the west and north parts of the county, and that the benefits of a POE are capitalized even by properties distant from the POE.

Table 4.10. Multi-family—Improvement Value Model GWR Summary Statistics

	Local coefficient estimates			Std. Error		
Variable	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
Intercept	-529799	-10366835	2186593	147845	32674	982772
ImpAge	3208	-13095	57959	862	197	5039
Depreciable	5129	-21392	95903	1121	303	9659
ImpSize	16.1	8.53	25.0	0.229	0.037	2.03
PCI_CY	3.00	-8.69	44.0	1.25	0.575	5.36
DistInterstate	-2.18	-259	98.3	4.87	1.06	12.1
DistFreeways	-7.68	-83.8	106	4.73	0.958	11.7
DistMajorArteries	-16.0	-359	67.9	8.17	2.98	14.6

POE_DrivingTime	7062	-119238	175832	7349	2264	19160
Residual Squares: 9512452005028 Effective Number: 17.3		Sigma: 117696 AICc: 18449		R^2: 0.760 AdjR^2: 0.754		

The GWR global diagnostics show improvement over OLS for the AIC_c from 240,655 to 18,449 respectively; however, AdjR^2 also decreased slightly, like in the *TotValue* model, from 0.828 in OLS to 0.754 in the GWR baseline model. Figure 4.10 illustrates the spatial autocorrelation test results on the standard residuals from the multi-family land value model for a) OLS and b) GWR. Results indicate that spatial autocorrelation is a problem in the residuals from the OLS model with cold spots predominantly on the west side and some on the east side, indicating intense clustering of low values, shown in blue in Figure 4.10(a). Spatial autocorrelation practically disappears in the GWR residuals, as shown in light yellow Figure 4.10(b).

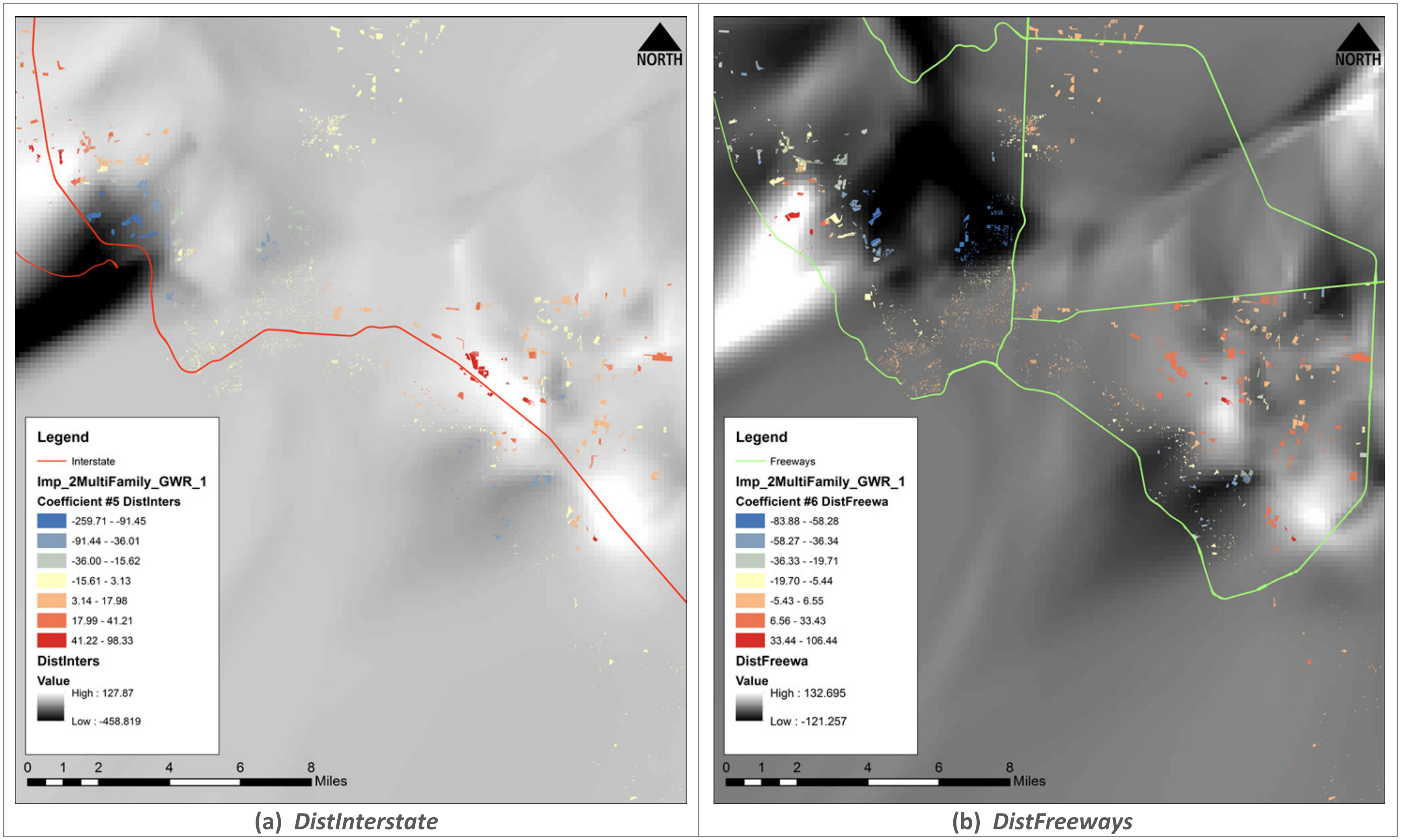
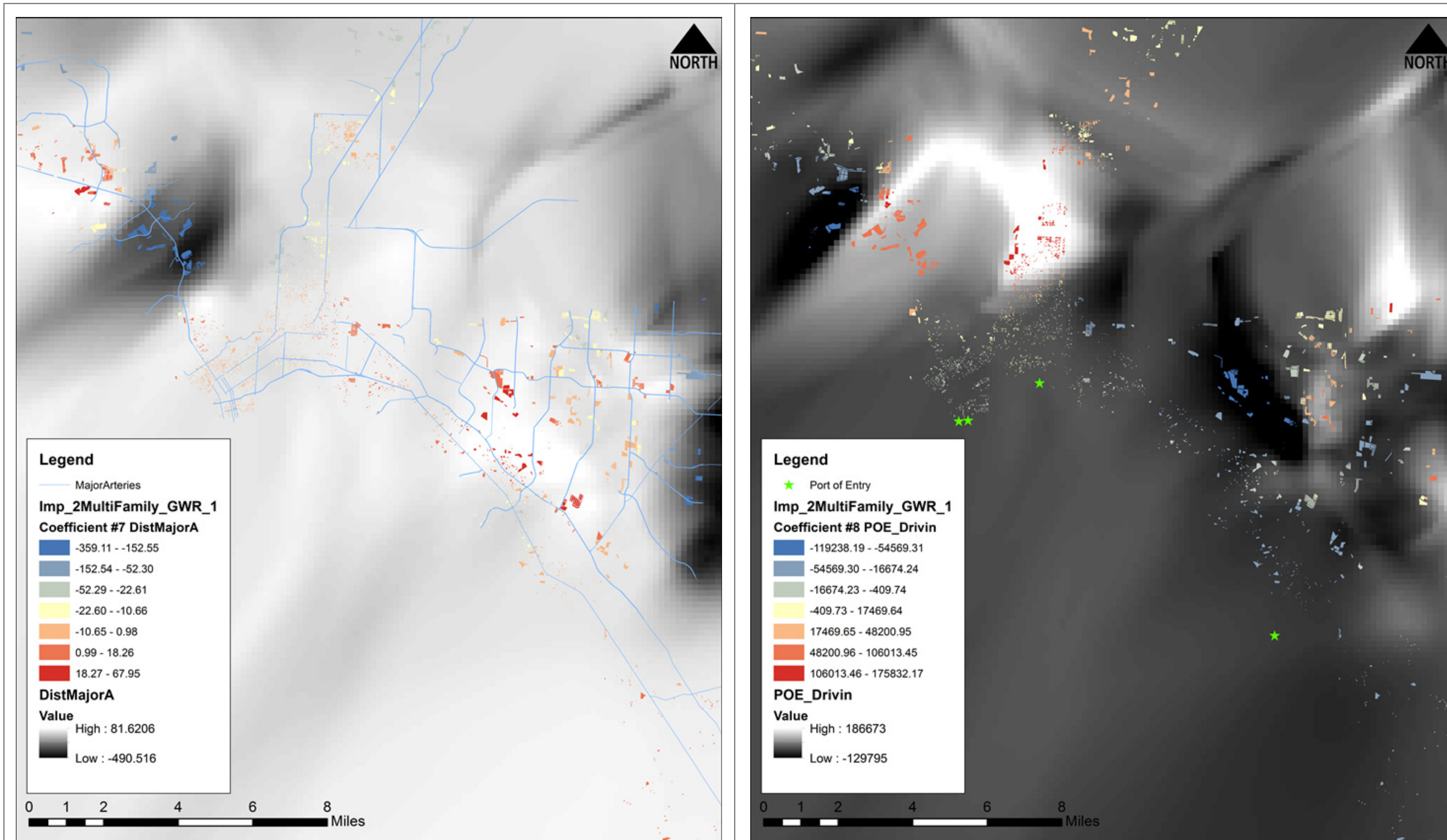
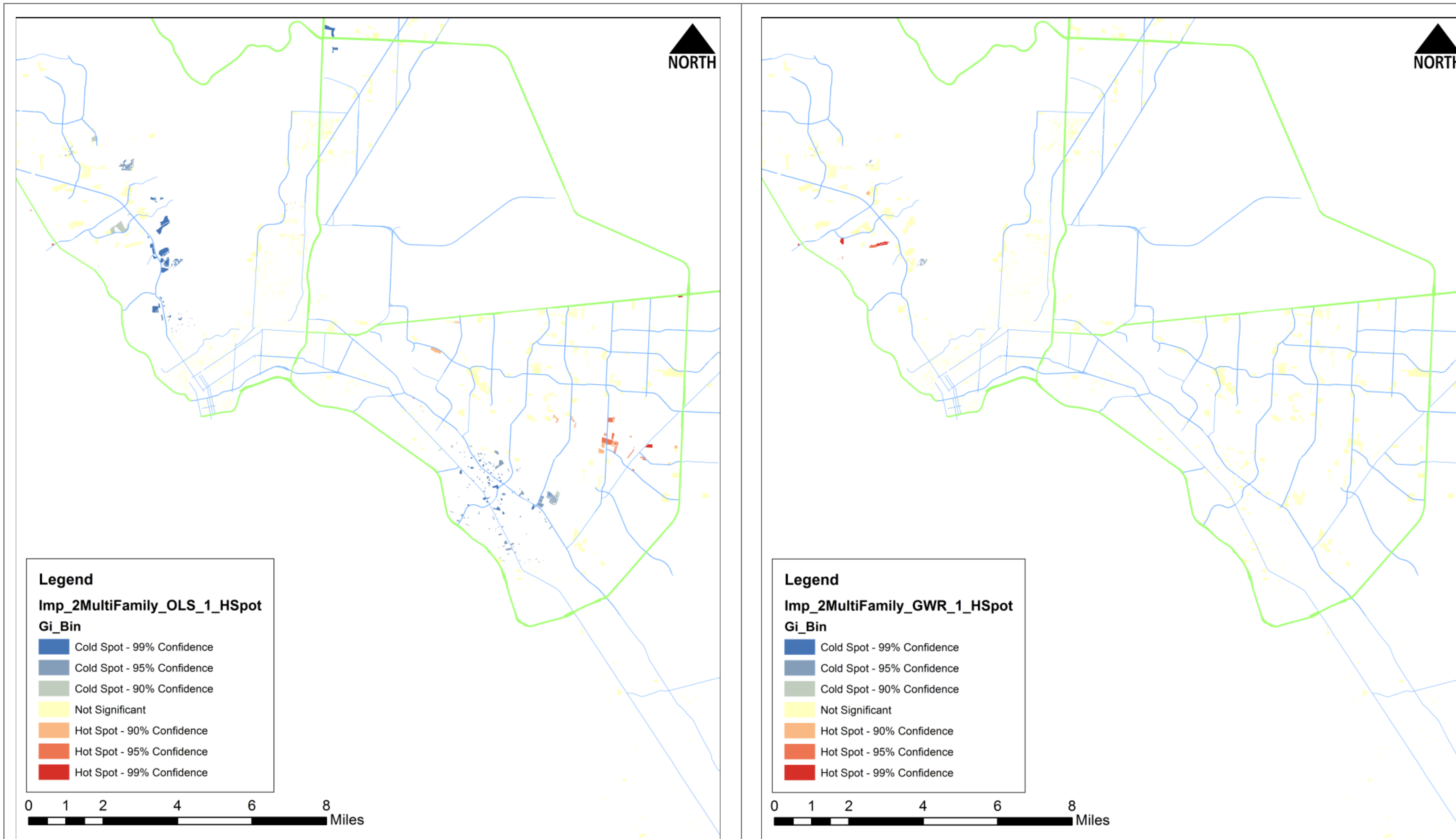


Figure 4.9. Multi-family Improvement Value GWR Model Coefficient Estimates.



(c) *DistMajorArteries* (d) *POE_DrivingTime*

Figure 4.9. Multi-family Improvement Value GWR Model Coefficients (continuation).



a) OLS Getis and Ord's G_i Test Results

b) GWR Getis and Ord's G_i Test Results

Figure 4.10. Multi-family Improvement Value Model Spatial Autocorrelation Test Results.

4.2.3. Multi-family Land Value Model

The land value sample consists of 8,373 data points (2.4% of the total population). The dependent variable is *LandValue*$_i$ for multi-family units. Table 4.11 summarizes the results for the 6 independent variables plus the intercept term, for which 5 parameters are statistically significant according to their robust probabilities. *LandValue* increases \$0.58 per foot in *DistInterstate*; \$0.32 per foot in *DistFreeways*; and \$3.65 per foot in *DistMajorArteries*. Similarly, *LandValue* increases \$871 for every additional minute in *POE_DrivingTime*. As in the *TotValue* and *ImpValue* models, *ShopC_DrivingTime* is not significant for *LandValue*. Adjusted R^2 indicates that the land model explains 78.7% of the variation. The significant Jarque-Bera statistic indicates that residuals are not normal. The Koenker BP statistic is significant confirming nonstationarity or heteroskedasticity issues. The Joint Wald Statistic indicates that the overall model is significant.

Table 4.11. Multi-family—Land Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	8771.94	3340.32	2.63	0.01*	4874.09	1.80	0.07	--------
LandAcres	93689.29	534.43	175.31	0.00*	13108.38	7.15	0.00*	1.00
DistInterstate	0.58	0.09	6.18	0.00*	0.08	7.47	0.00*	1.52
DistFreeways	0.32	0.15	2.15	0.03*	0.16	2.01	0.04*	1.66
DistMajorArteries	3.65	0.85	4.31	0.00*	0.82	4.45	0.00*	1.25
POE_DrivingTime	870.97	224.05	3.89	0.00*	183.09	4.76	0.00*	1.70
ShopC_DrivingTime	443.59	285.41	1.55	0.12	306.88	1.45	0.15	1.26

Observations:	8373	AICc:	212638
Multiple R-Squared:	0.788	Adjusted R-Squared:	0.787
Joint F-Statistic:	5163	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	278	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	2229	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	499057983	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

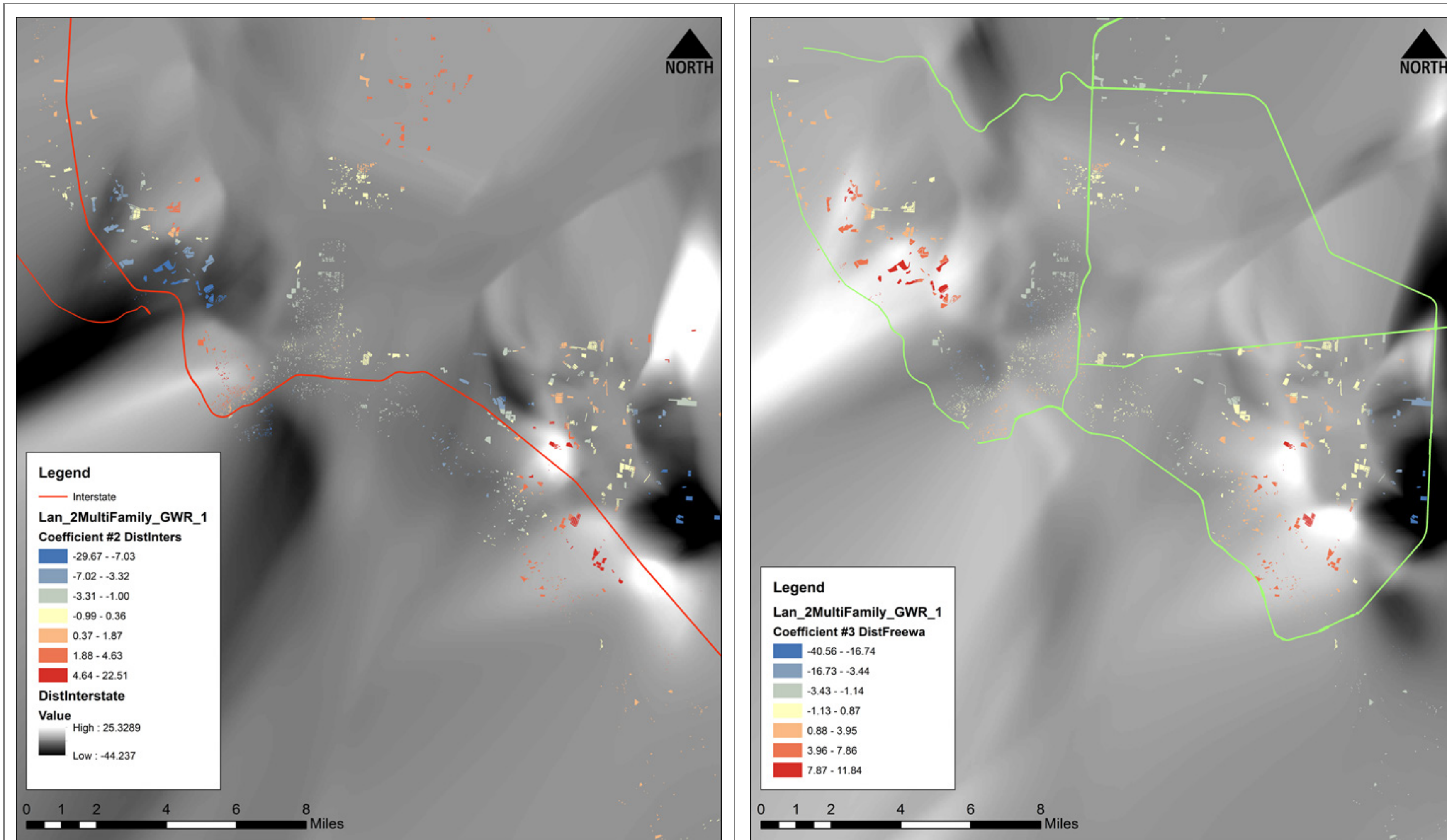
The GWR land value model yields 8,373 regression points with invertible matrices, which represent 100% from the multi-family sample (see Table 4.12). The mean values of the local coefficients for *DistInterstate* and *DistMajorArteries* show smaller magnitudes and signs that run counter to the OLS parameter estimation. *DistFreeways* and *POE_DrivingTime* are both positive, consistent with the OLS counterparts. As shown by Figure 4.11, the premia for *DistInterstate* is

higher for the land located in the north part of the county; however, a significant number of parcels indicate no impact and some negative coefficients occur in the west. As *DistInterstate* increases, *LandValue* decreases \$0.27 per foot according to the mean. *DistInterstate* ranges from a negative \$29.60 to a positive \$22.50 per foot depending on their location, as shown in Figure 4.11(a). As *DistFreeways* increases, *LandValue* increases \$0.64 per foot according to the mean. Coefficients from *DistFreeways* range from a negative \$40.50 per foot to an increase of \$11.80 per foot, as shown in Figure 4.11(b). *DistMajorArteries* indicates that *LandValue* decreases \$3.65 per foot according to the mean. Coefficients from *DistMajorArteries* range from a negative \$105 per foot to an increase of \$18.70 per foot, as shown in Figure 4.11(c). *POE_DrivingTime* indicates that for every additional driving minute to the nearest POE, the *LandValue* increases almost \$148 on average. Coefficients from *POE_DrivingTime* range from a negative \$15,195 per minute to an increase of \$65,952 per minute, as shown in Figure 4.11(d).

Table 4.12. Multi-family—Land Value Model GWR Summary Statistics

	Local coefficient estimates			Std. Error		
Variable	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
Intercept	-9919	-1583834	196022	32782	5949	112865
LandAcres	106666	34179	253669	4104	729	27597
DistInterstate	-0.27	-29.6	22.5	2.00	0.453	5.44
DistFreeways	0.646	-40.5	11.8	1.99	0.373	4.74
DistMajorArteries	-3.65	-105	18.7	3.52	1.28	6.40
POE_DrivingTime	148	-15195	65952	3065	980	7957
Residual Squares:	5050950764219	Sigma: 53104		R^2: 0.882		
Effective Number:	39.94	AICc: 45064		AdjR^2: 0.881		

The GWR global diagnostics show improvement over OLS for the AIC_c from 212,638 to 45,064 respectively, and AdjR^2 improved from 0.787 in OLS to 0.881 in the GWR baseline model. Figure 4.12(a) indicates that spatial autocorrelation is a problem in the residuals from OLS, with hot spots predominantly in the west and also close to downtown, indicating intense clustering of high values in red. Cold spots dominate the central part of the county and the outer north and east, as shown in blue. Spatial autocorrelation practically disappears in the residuals from GWR, as shown in light yellow in Figure 12(b).



(a) *DistInterstate* (b) *DistFreeways*

Figure 4.11. Multi-family Land Value GWR Model Coefficients.

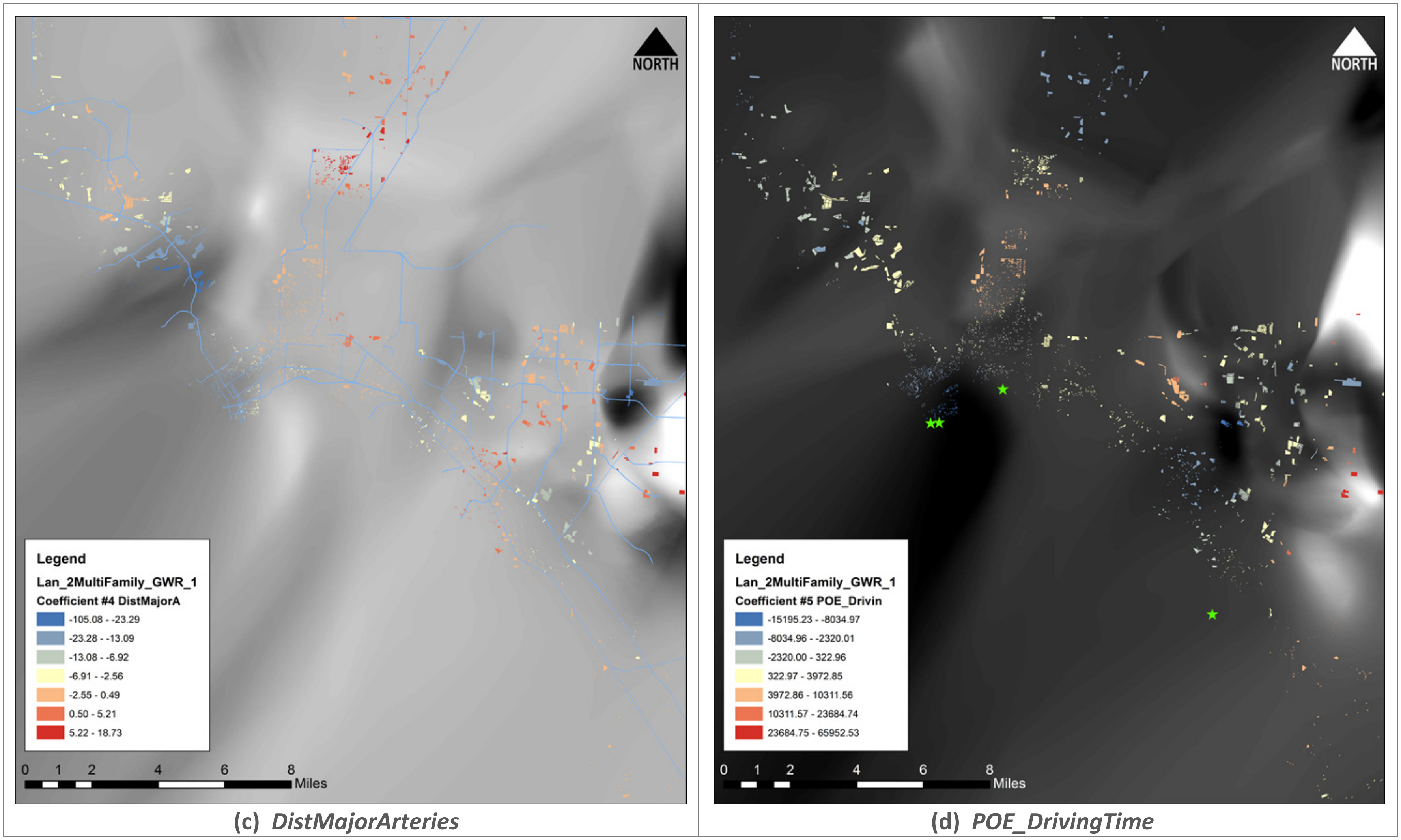
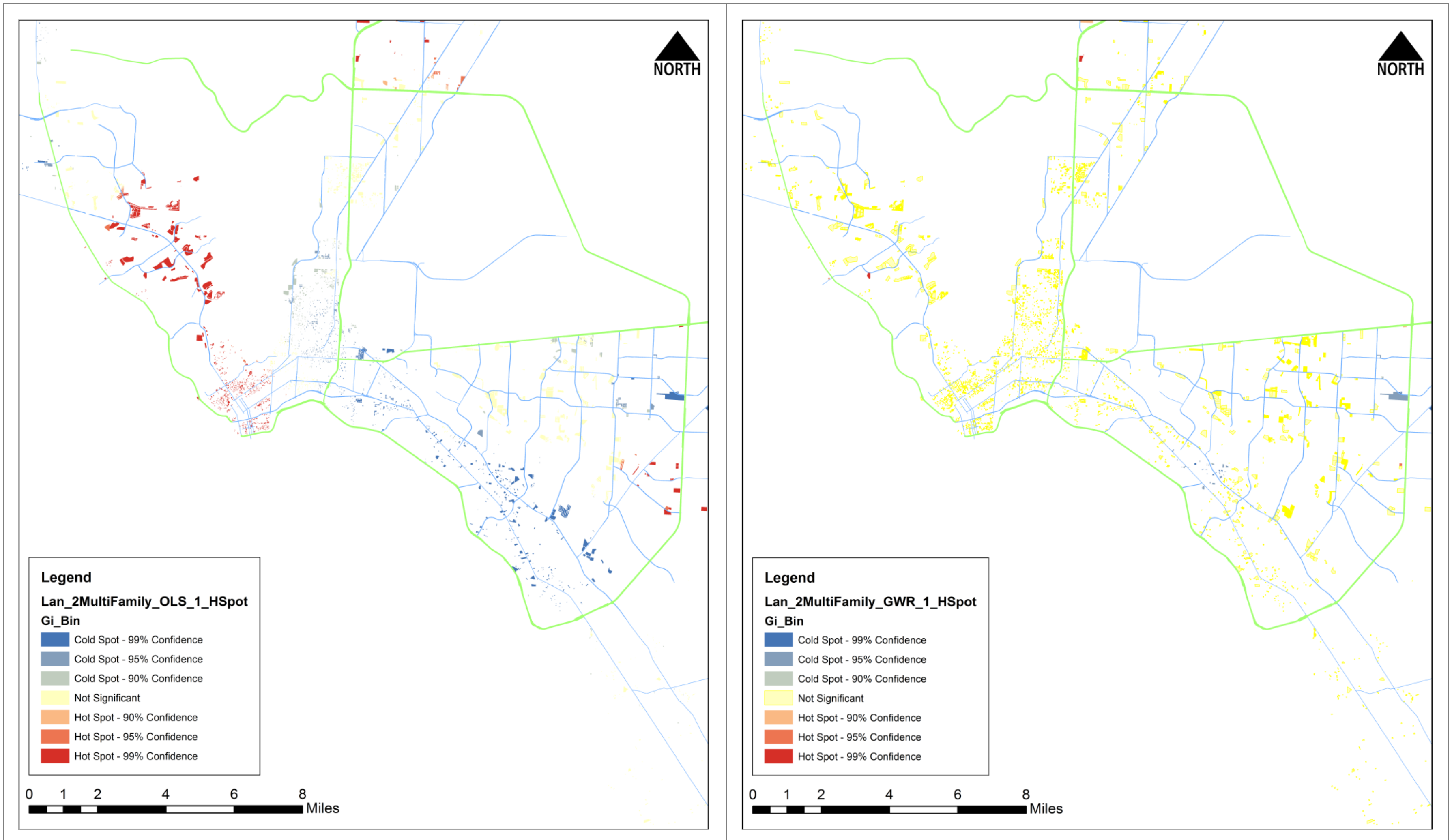


Figure 4.11. Multi-family Land Value GWR Model Coefficients (continuation).



a) OLS Getis and Ord's G_i Test Results

b) GWR Getis and Ord's G_i Test Results

Figure 4.12. Multi-family Land Value Model Spatial Autocorrelation Test Results.

4.3. Other-residential

4.3.1. Other-residential Total Value Model

The total value sample for other-residential consists of 18,808 observations (5.3% of the total population). The dependent variable is $TotValue_i$. Table 4.13 reports the results for the 21 independent variables plus the intercept term, from which 19 are statistically significant according to the robust 95% confidence interval. *Mp35003a_B* does not significantly impact *TotValue* for other-residential. *TotValue* decreases \$0.28 per foot as *DistInterstate* increases. *DistFreeways* indicate a similar decrease of \$0.25 per foot in *TotValue*. *DistMajorArteries* indicates a decrease in *TotValue* of \$0.31 for every foot away from the nearest major artery. *POE_DrivingTime* indicates that for every minute it takes to drive to the nearest POE, *TotValue* increases \$386. Similarly, *ShopC_DrivingTime* indicates that *TotValue* increases \$376 per minute driving to the nearest shopping center. Adjusted R^2 indicates that the model explains 56.0% of the variation. The significant large value of the Jarque-Bera statistic indicates that residuals are not normally distributed. The Koenker BP statistic is significant indicating nonstationarity or heteroskedasticity. The Joint Wald Statistic indicates that the overall model is significant.

Table 4.13. Other-residential—Total Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	-9546.12	1548.98	-6.16	0.00*	3303.22	-2.89	0.00*	--------
ImpAge	274.42	23.77	11.54	0.00*	50.53	5.43	0.00*	3.59
Air	20405.88	962.73	21.20	0.00*	3338.80	6.11	0.00*	1.36
$Baths^2$	3678.32	116.38	31.61	0.00*	1517.22	2.42	0.02*	1.71
$Bedrooms^2$	2530.85	104.20	24.29	0.00*	531.42	4.76	0.00*	1.53
Garage	31467.27	2562.58	12.28	0.00*	6808.62	4.62	0.00*	1.12
Depreciable	279.32	11.68	23.91	0.00*	29.78	9.38	0.00*	2.43
LandAcres	1052.04	82.35	12.78	0.00*	609.81	1.73	0.08	1.23
ImpSize	2.28	0.13	17.34	0.00*	1.52	1.50	0.13	1.28
Stories	-4570.93	733.64	-6.23	0.00*	667.80	-6.84	0.00*	3.73
Vacant	-23903.43	722.83	-33.07	0.00*	874.48	-27.33	0.00*	3.46
PopDens_CY	0.18	0.09	2.04	0.04*	0.09	2.10	0.04*	1.41
Renter_CY	8.59	1.46	5.89	0.00*	2.22	3.88	0.00*	1.99
Vacant_CY	-43.22	7.06	-6.12	0.00*	6.49	-6.65	0.00*	2.65
Unemp_CY	-35.64	3.51	-10.14	0.00*	3.14	-11.36	0.00*	1.60
PCI_CY	1.18	0.03	41.14	0.00*	0.09	12.74	0.00*	2.25
Mp35003a_B	-2.84	3.44	-0.83	0.41	6.72	-0.42	0.67	2.29

DistInterstate	-0.28	0.02	-17.04	0.00*	0.02	-11.64	0.00*	2.60
DistFreeways	-0.25	0.01	-18.56	0.00*	0.02	-14.47	0.00*	2.70
DistMajorArteries	-0.31	0.05	-6.21	0.00*	0.04	-6.99	0.00*	1.78
POE_DrivingTime	385.72	41.04	9.40	0.00*	39.08	9.87	0.00*	2.26
ShopC_DrivingTime	375.87	45.44	8.27	0.00*	61.19	6.14	0.00*	3.31

Observations:	18808	AICc:	435404
Multiple R-Squared:	0.560	Adjusted R-Squared:	0.560
Joint F-Statistic:	1140	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	8282	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	628	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	151546055	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

The GWR total value equation estimate yields 16,954 regression points with invertible matrices, which represent 90.1% from the other-residential sample (see Table 4.14). The mean values of the local coefficients show positive signs for *DistInterstate* and *DistFreeways*, opposite those of the OLS coefficients. The *DistMajorArteries* parameters have negative signs on both the OLS and the mean GWR estimates, and both magnitudes are very close in value. Figure 4.13 charts the spatial variation of the transportation infrastructure impacts in the *TotValue* for other-residential properties. *DistInterstate* indicates that *TotValue* increases $0.37 per foot according to the mean. Coefficients from *DistInterstate* range from a negative $16.10 to a positive $18.80 per foot depending on their location, as shown in Figure 4.13(a). *DistFreeways* indicates that *TotValue* increases $0.35 per foot according to the mean. *DistFreeways* ranges from a negative $36.10 to a positive $28.10 per foot depending on their location, as shown in Figure 4.13(b). *DistMajorArteries* indicates that *TotValue* decreases $0.49 per foot according to the mean. Local coefficients for *DistMajorArteries* range from a negative $46.30 to a positive $39.10 per foot, as shown in Figure 4.13(c). According to the mean *POE_DrivingTime*, *TotValue* increases $845 for every additional minute required to drive to the nearest POE. *POE_DrivingTime* ranges from a negative $12,354 per minute to a positive *TotValue* of $33,332 per minute, as shown in Figure 4.13(d). Although *POE_DrivingTime* shows positive signs in both the estimation of OLS and mean coefficients in GWR, Figure 13(d) shows that negative coefficients predominate throughout the county in GWR, as shown in blue.

Table 4.14. Other Residential—Total Value Model GWR Summary Statistics

	Local coefficient estimates			Std. Error		
Variable	Mean	Min	Max	Mean	Min	Max
Intercept	-53067	-2534513	236731	10430	2777	57372
ImpAge	708	-401	15715	69.3	29.1	478
Depreciable	572	-947	24666	51.5	14.8	573
PCI_CY	0.088	-9.43	20.4	0.215	0.035	1.44
DistInterstate	0.372	-16.1	18.8	0.272	0.069	2.00
DistFreeways	0.355	-36.1	28.1	0.263	0.075	0.725
DistMajorArteries	-0.497	-46.3	39.1	0.477	0.160	2.07
POE_DrivingTime	845	-12354	33332	381	62.9	1033
Residual Squares:	1677429866	Sigma:	9163	R^2:	0.838	
Effective Number:	2.02	AICc:	467	$AdjR^2$:	0.829	

The GWR global diagnostics indicate improvement over OLS for the AIC_c from 435,404 to 467 respectively, and $AdjR^2$ improved from 0.561 in OLS to 0.829 in the GWR baseline model. Figure 4.14(a) indicates that spatial autocorrelation is a problem in the residuals from the OLS model with hot spots predominantly in the west side and southeast parts of the county, indicating intense clustering of high values in red. Cold spots dominate the outer west and east sides of the county, as shown in blue. Spatial autocorrelation is largely absent from the GWR residuals, as shown in light yellow in Figure 4.14(b).

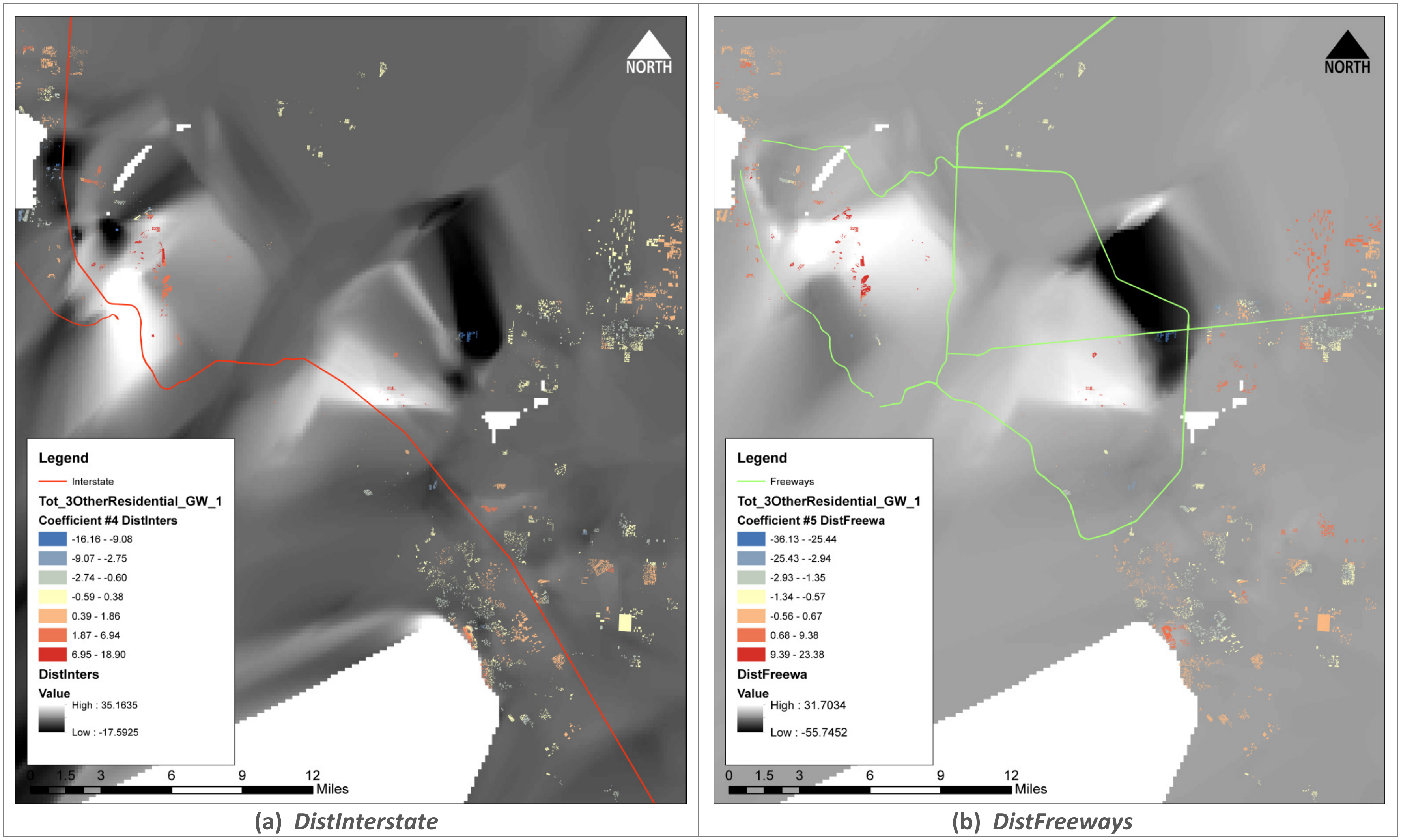
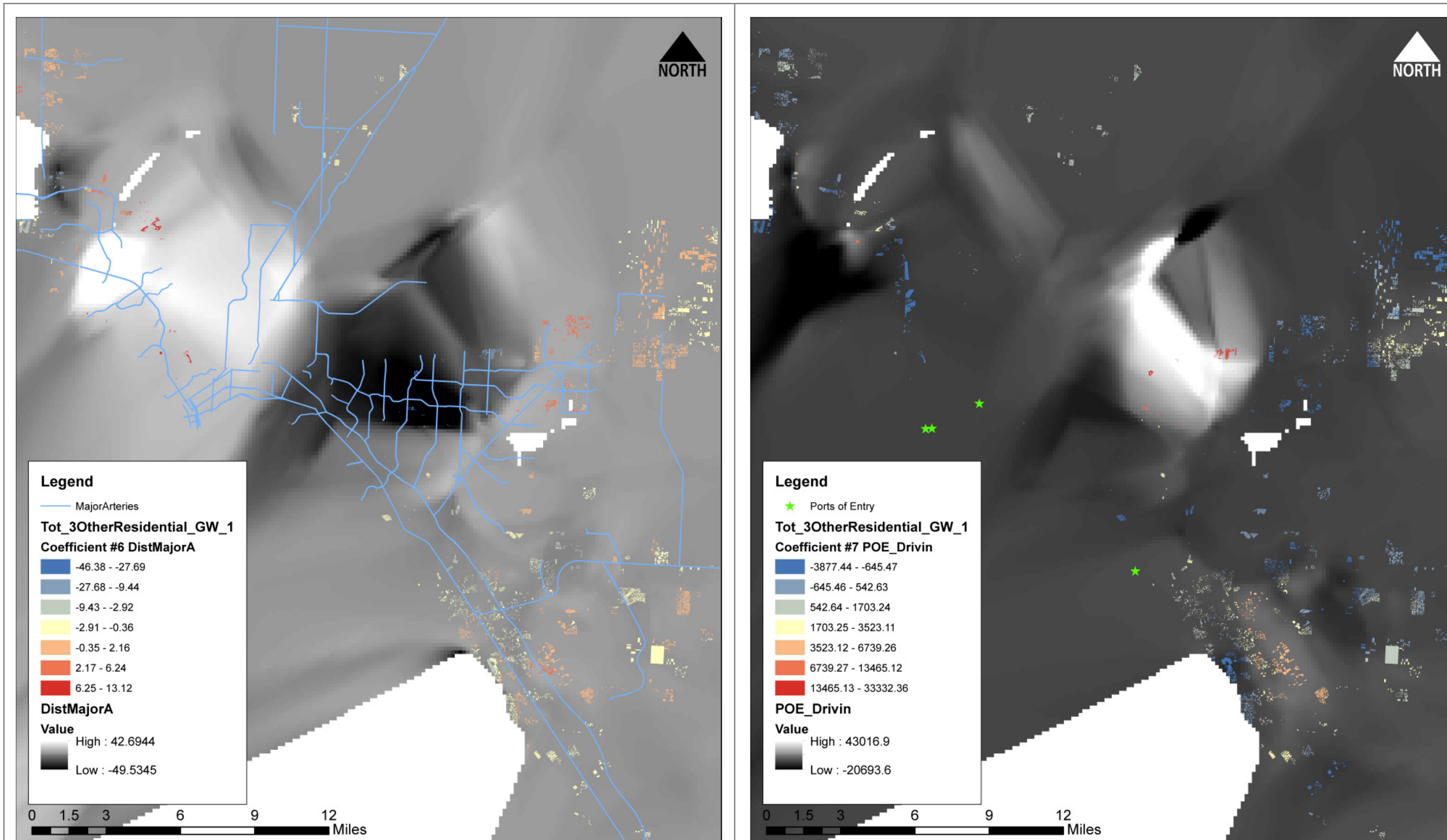


Figure 4.13. Other-residential Total Value GWR Coefficients.



(c) *DistMajorArteries* (d) *POE_DrivingTime*

Figure 4.13. Other-residential Total Value GWR Coefficients (continuation).

Figure 4.14. Other-residential Total Value Model Spatial Autocorrelation Test Results.

4.3.2. Other-residential Improvement Value Model

The improvement value sample contains 18,808 data points (5.3% of the total population). The dependent variable is $ImpValue_i$ for other-residential. Table 4.15 summarizes the results for the 20 independent variables plus the intercept term, for which 18 coefficients are statistically significant according to robust 95% confidence intervals. *Mp35003a_B* indicates that *ImpValue* decreases $15.21 per person with 3 air-trips per year. Other-residential *ImpValue* decreases $0.21 for every foot *DistInterstate* increases. *DistFreeways* indicates a similar decrease of $0.10 per foot. *DistMajorArteries* exhibits a decrease in *ImpValue* of $0.11 per foot. *POE_DrivingTime* indicates that *ImpValue* increases $274 for every additional minute driving to the nearest POE. *ShopC_DrivingTime* is not significant. Adjusted R^2 indicates that this model explains 63.8% of the variation. The residuals are not normal, as indicated by a significant Jarque-Bera statistic. Spatial nonstationarity and heteroskedasticity issues are confirmed by the significant Koenker BP statistic. The overall model is significant as indicated by the Joint Wald statistic.

Table 4.15. Other Residential—Improvement Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	-37115.57	1171.60	-31.68	0.00*	3579.32	-10.37	0.00*	----
ImpAge	459.64	19.49	23.59	0.00*	53.66	8.57	0.00*	3.55
Air	24879.85	791.79	31.42	0.00*	3359.69	7.41	0.00*	1.36
$Baths^2$	3610.53	95.84	37.67	0.00*	1528.13	2.36	0.02*	1.71
$Bedrooms^2$	2146.17	85.46	25.11	0.00*	526.46	4.08	0.00*	1.52
Garage	26563.23	2110.16	12.59	0.00*	6863.54	3.87	0.00*	1.12
Depreciable	267.66	9.62	27.83	0.00*	29.37	9.11	0.00*	2.43
LandAcres	1113.18	67.55	16.48	0.00*	666.76	1.67	0.10	1.22
ImpSize	2.06	0.11	19.03	0.00*	1.42	1.45	0.15	1.28
Stories	12069.94	435.12	27.74	0.00*	590.83	20.43	0.00*	1.93
PopDens_CY	1.06	0.07	14.85	0.00*	0.09	12.29	0.00*	1.35
Renter_CY	4.57	1.20	3.81	0.00*	1.73	2.65	0.01*	1.99
Vacant_CY	-56.31	5.79	-9.72	0.00*	5.97	-9.43	0.00*	2.63
Unemp_CY	-15.52	2.89	-5.37	0.00*	2.73	-5.69	0.00*	1.60
PCI_CY	1.05	0.02	44.82	0.00*	0.09	11.87	0.00*	2.19
Mp35003a_B	-15.21	2.83	-5.37	0.00*	6.39	-2.38	0.02*	2.28
DistInterstate	-0.21	0.01	-15.92	0.00*	0.02	-9.96	0.00*	2.60
DistFreeways	-0.10	0.01	-9.39	0.00*	0.01	-7.15	0.00*	2.67
DistMajorArteries	-0.11	0.04	-2.59	0.01*	0.04	-2.57	0.01*	1.78
POE_DrivingTime	274.62	33.79	8.13	0.00*	35.20	7.80	0.00*	2.26
ShopC_DrivingTime	27.65	37.41	0.74	0.46	48.21	0.57	0.57	3.31

Observations:	18808	AICc:	428101
Multiple R-Squared:	0.639	Adjusted R-Squared:	0.638
Joint F-Statistic:	1661	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	10869	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	8014	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	3137736	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

The GWR improvement value model has 16,965 regression points with invertible matrices, which represent 90.2% from the other-residential sample (see Table 4.16). The mean local coefficients for *DistInterstate* and *DistFreeways* show signs contrary to their OLS estimation. The mean values of the *DistMajorArteries* and *POE_DrivingTime* parameters are consistent with the OLS coefficients. As shown by Figure 4.15, the premia for *DistInterstate* and *DistFreeways* is higher for the land located in the west side of the county. As *DistInterstate* increases, *ImpValue* increases $0.17 per foot according to the mean. *DistInterstate* ranges from a negative $13.00 per foot to an increase of $16.70 per foot depending on their location, as shown in Figure 4.15(a). As *DistFreeways* increases, *ImpValue* increases $0.56 per foot according to the mean. Coefficients from *DistFreeways* range from a negative $16.00 per foot to a positive $20.80 per foot, as shown in Figure 4.15(b). *DistMajorArteries* indicates that *ImpValue* decreases $0.86 per foot according to the mean. Local coefficients for *DistMajorArteries* range from a negative $43.70 per foot to a positive $25.50 per foot, as shown in Figure 4.15(c). *POE_DrivingTime* indicates that for every additional driving minute to the nearest POE, the *ImpValue* increases almost $349 on average. Coefficients from *POE_DrivingTime* range from a negative $10,410 per minute to a positive $16,074 per minute depending on their location, as shown in Figure 4.15(d). A significant number of parcels located in the east side indicate no impact. *POE_DrivingTime* shows negative coefficients predominating throughout the county, as seen in blue in Figure 4.15(d).

Table 4.16. Other Residential—Improvement Value Model GWR Summary Statistics

	Local coefficient estimates			Std. Error		
Variable	Mean	Min	Max	Mean	Min	Max
Intercept	37515	-303984	1037673	14264	3744	52759
$Baths^2$	5321	-10933	20310	2029	135	7369
$Bedrooms^2$	1174	-5606	7787	1000	122	3486
Depreciable	-384	-10400	271	44.6	16.6	384

PCI_CY	-0.042	-4.41	8.68	0.369	0.060	2.48
DistInterstate	0.174	-13.0	16.7	0.467	0.120	3.52
DistFreeways	0.567	-16.0	20.8	0.454	0.116	1.24
DistMajorArteries	-0.869	-43.7	25.5	0.820	0.276	3.65
POE_DrivingTime	349	-10410	16074	658	98.0	1777
Residual Squares:	13334180980	Sigma:	15752	R^2:	0.340	
Effective Number:	3.26	AICc:	1267	$AdjR^2$:	0.312	

The GWR global diagnostics show improvement over OLS for the AIC_c from 428,101 to 1,267 respectively. However, $AdjR^2$ decreased significantly in the *ImpValue* model, from 0.638 in OLS to 0.312 in the GWR baseline model. Figure 4.16 illustrates the spatial autocorrelation test results on the standard residuals from the other-residential model for a) OLS and b) GWR. Results indicate that spatial autocorrelation is a problem in the OLS residuals. Hot spots are present in the west side of the county, where other-residential properties with high taxable values are located, and in the south eastern part of the county near San Elizario, as shown in red in Figure 4.16(a). Cold spots are present in mainly in the east side, as shown in blue in Figure 4.16(a). Spatial autocorrelation is largely absent from the GWR residuals, as shown in yellow in Figure 4.16(b).

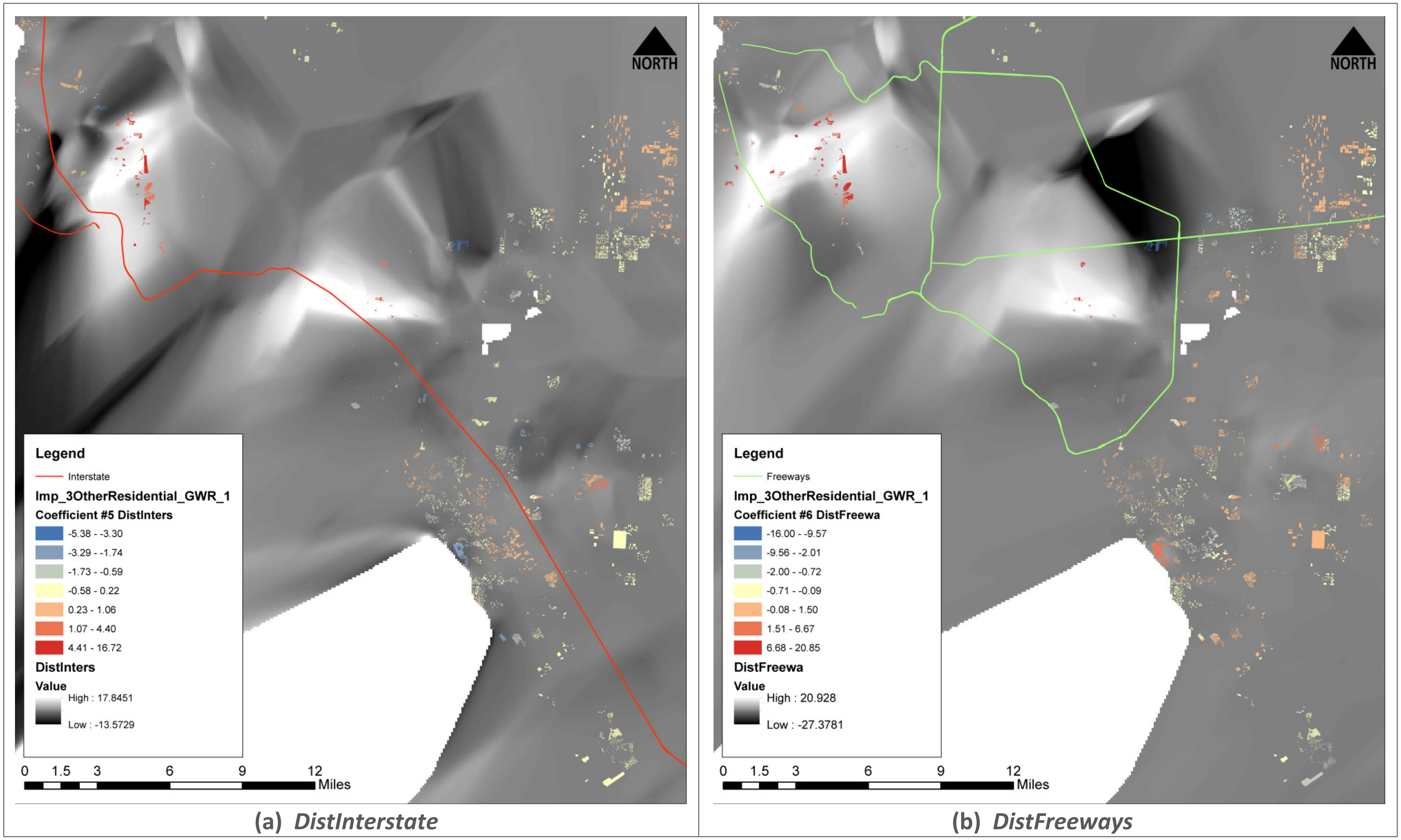
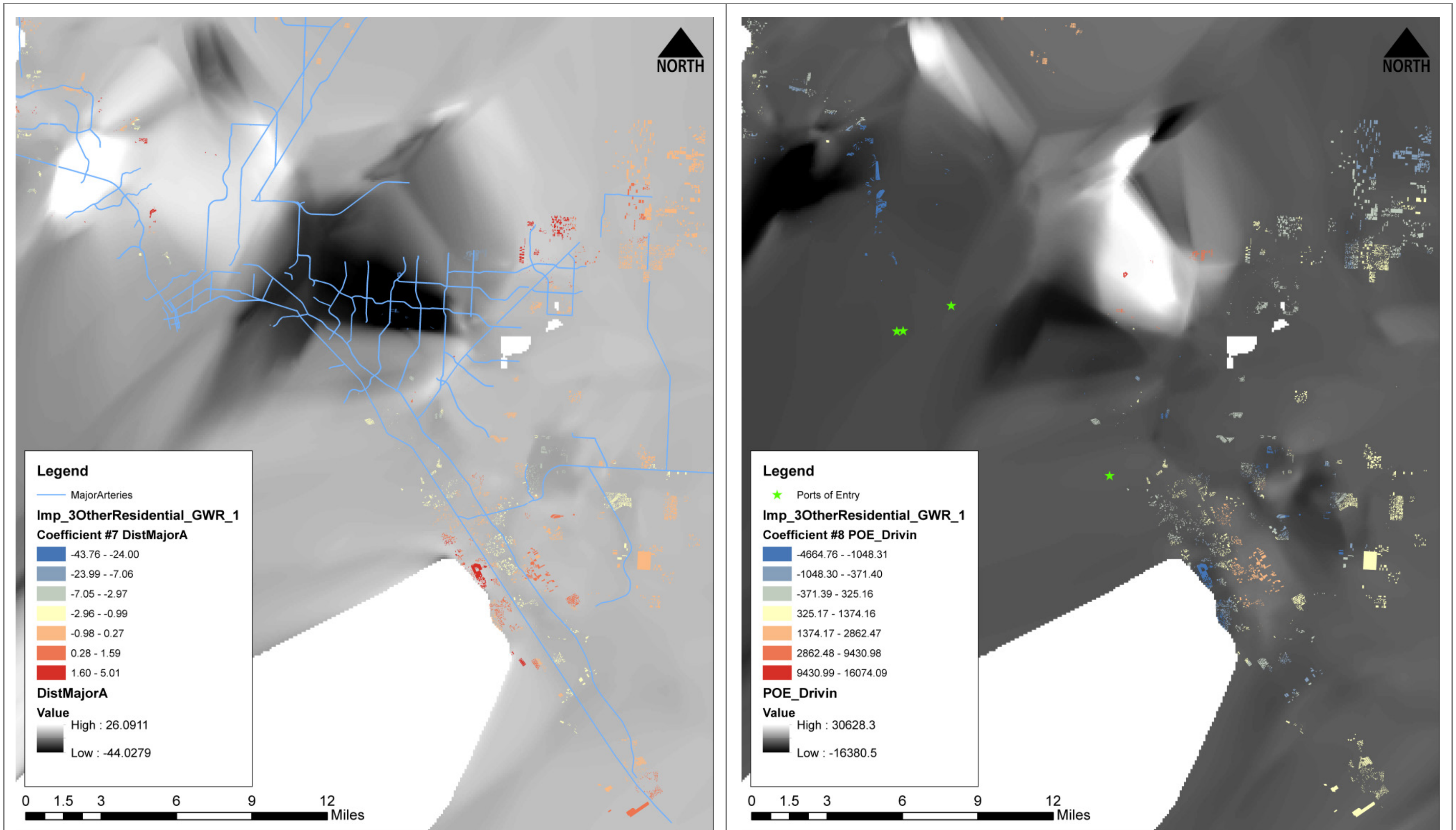


Figure 4.15. Other-residential Improvement Value GWR Model Coefficients.



(c) *DistMajorArteries* (d) *POE_DrivingTime*

Figure 4.15. Other-residential Improvement Value GWR Model Coefficients (continuation).

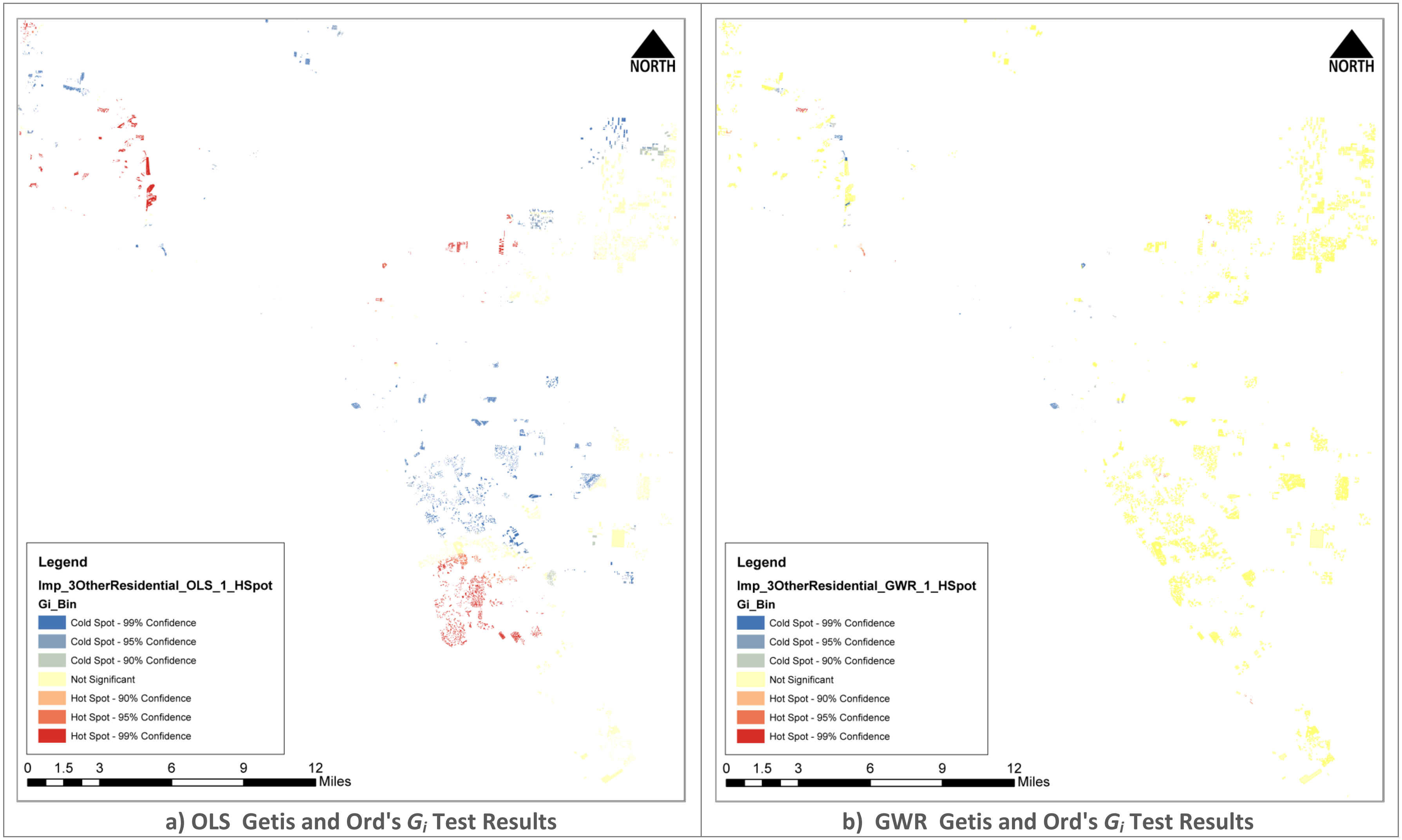


Figure 4.16. Other-residential Improvement Value Model Spatial Autocorrelation Test Results.

4.3.3. Other-residential Land Value Model

The land value sample consists of 18,808 data points (5.3% of the total population). The dependent variable is $LandValue_i$ for other-residential units. Table 4.17 summarizes parameter estimation results for the 6 independent variables plus the intercept term, all of which are statistically significant. *DistInterstate* indicates an increase in *LandValue* of \$0.08, *DistFreeways* an increase of \$0.13, and *DistMajorArteries* indicates an increase of \$0.16 for every foot a parcel is located away from the nearest transportation facility. *POE_DrivingTime* indicates that *LandValue* increases \$114 for every minute required to drive from a parcel to a POE, which implies that as distance to a POE increases, the *LandValue* of other-residential parcels increases. Similarly, as *ShopC_DrivingTime* increases, *LandValue* is \$379 higher per minute. AdjR^2 indicates that the land value model explains only 3.3% of the variation. A large and significant Jarque-Bera statistic indicates that the residuals are not normally distributed. From the 21 models in this study, this is the only model for which the Koenker BP statistic was not significant, indicating that nonstationarity and heteroskedasticity are not present. A Joint Wald Statistic indicates that the overall model is significant.

Table 4.17. Other Residential—Land Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	11225.08	396.32	28.32	0.00*	414.06	27.11	0.00*	------
LandAcres	483.90	41.85	11.56	0.00*	199.04	2.43	0.02*	1.01
DistInterstate	0.08	0.01	9.77	0.00*	0.01	7.38	0.00*	2.09
DistFreeways	0.13	0.01	19.44	0.00*	0.01	15.10	0.00*	2.27
DistMajorArteries	0.16	0.03	5.88	0.00*	0.02	6.70	0.00*	1.66
POE_DrivingTime	114.76	20.35	5.64	0.00*	17.48	6.57	0.00*	1.77
ShopC_DrivingTime	379.43	22.92	16.56	0.00*	35.39	10.72	0.00*	2.68

Observations:	18808	AICc:	413595
Multiple R-Squared:	0.033	Adjusted R-Squared:	0.033
Joint F-Statistic:	108	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	639	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	11	Prob(>chi-squared), (21) degrees of freedom:	0.08
Jarque-Bera Statistic:	12581665253	Prob(>chi-squared), (2) degrees of freedom:	0.00*

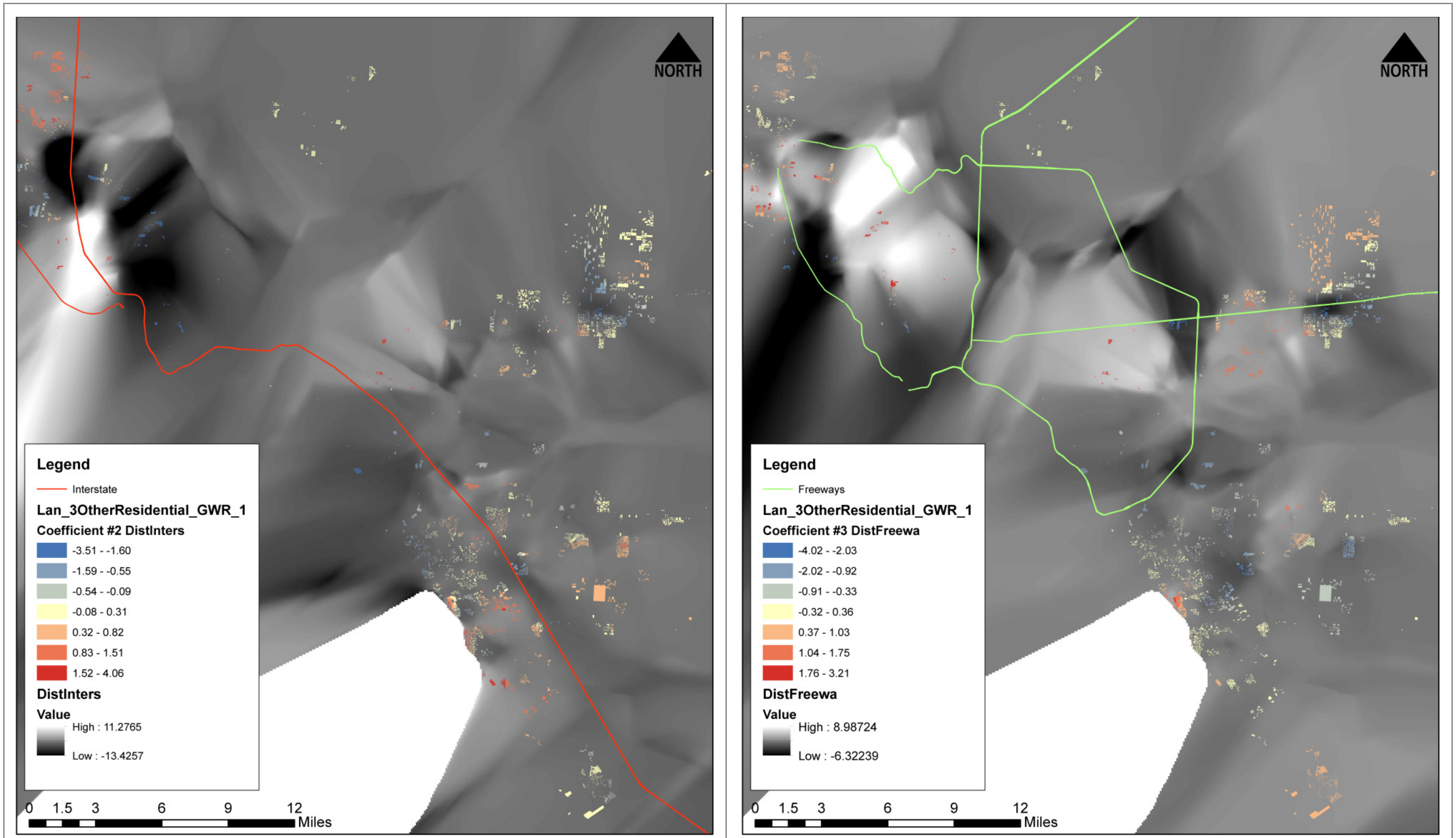
*Statistically significant probabilities have an asterisk next to them.

The GWR land value equation has 17,606 regression points with invertible matrices, which represent 93.6% from the other-residential sample (see Table 4.18). The mean local coefficients have signs that are consistent with the OLS estimated coefficients except for *DistInterstate*. For *DistFreeways, DistMajorArteries*, and *POE_DrivingTime*, Figure 4.17 indicates a higher premia predominantly on the west side of the county. *LandValue* decreases $0.10 per foot in *DistInterstate* according to the mean. Local coefficients for *DistInterstate* range from a negative $10.80 per foot to a positive $1,844 per foot depending on their location, as shown in Figure 4.17(a). *DistFreeways* indicates that *LandValue* increases $0.17 per foot according to the mean. *DistFreeways* ranges from a negative $6.20 to a positive $8.60 per foot, as shown in Figure 4.17(b). *DistMajorArteries* indicates that *LandValue* increases $0.55 per foot according to the mean. Coefficients from *DistMajorArteries* range from a negative $11.70 to a positive $15.80 per foot, as shown in Figure 4.17(c). According to the mean, *POE_DrivingTime* indicates that *LandValue* increases $73.40 per minute driving to the nearest POE. Coefficients from *POE_DrivingTime* range from a negative $7,250 to a positive $7,344 per minute in *LandValue*, as shown in Figure 4.17(d). Parcels with higher premia for *POE_DrivingTime* are observed on the western outskirts of the county and some in the east, as seen in red, most of them located distant to the POEs. *ShopC_DrivingTime* indicates that *TotValue* increases $35.10 per minute required to drive to the nearest shopping center according to the mean. *ShopC_DrivingTime* ranges from a negative $4,752 per minute to an increase in *LandValue* of $6,351 per minute, as shown in Figure 4.17(e). *ShopC_DrivingTime* indicates a significant number of parcels spread throughout the county for which the premia are either null or negative.

Table 4.18. Other Residential—Land Value Model GWR Summary Statistics

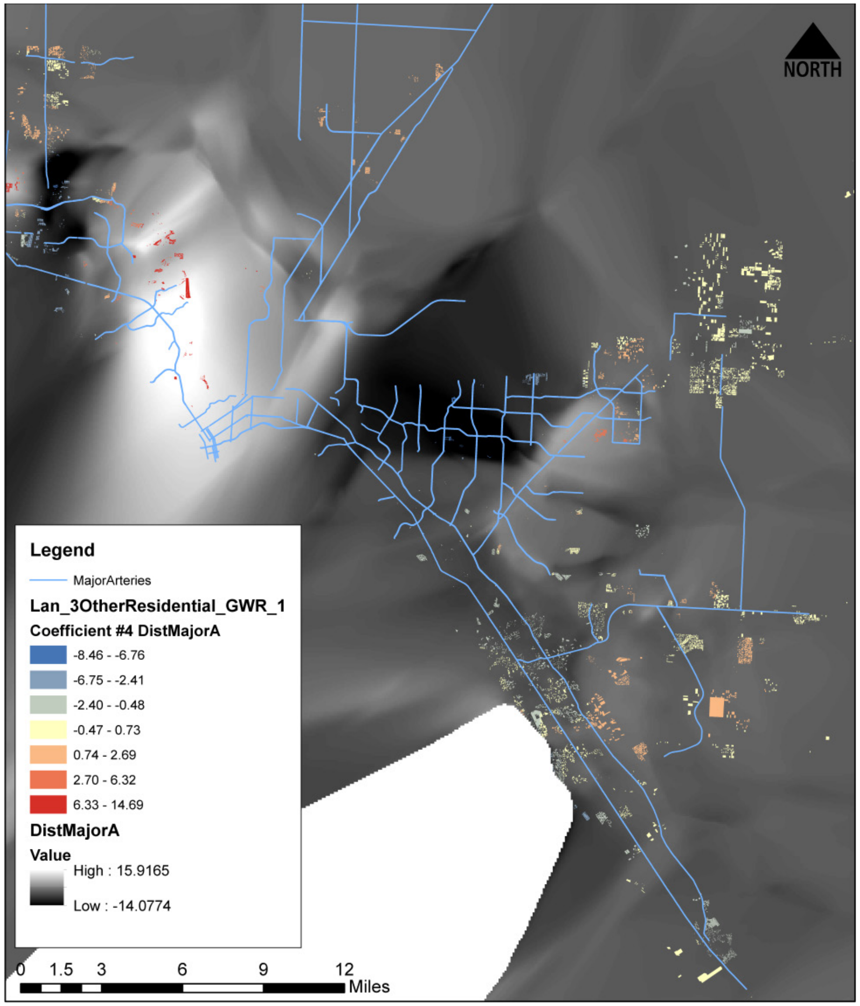
	Local coefficient estimates			Std. Error		
Variable	Mean	Min	Max	Mean	Min	Max
Intercept	6589	-172285	123210	5283	1123	20796
LandAcres	15069	-3455	204638	812	25.5	5783
DistInterstate	-0.104	-10.8	1844	0.188	0.054	1.374
DistFreeways	0.169	-6.27	8.60	0.173	0.031	0.611
DistMajorArteries	0.559	-11.7	15.8	0.322	0.097	1.44
POE_DrivingTime	73.4	-7250	7344	338	30.0	1380
ShopC_DrivingTime	35.1	-4752	6351	350	57.9	1220
Residual Squares:	2620741211	Sigma:	6158	R^2:	0.684	
Effective Number:	2.90	AICc:	1464	$AdjR^2$:	0.675	

The GWR global diagnostics show substantial improvement over OLS for the AIC_c from 413,595 to 1,464. Likewise, $AdjR^2$ improved significantly in the GWR *LandValue* model, from 0.03 in OLS to 0.675 in the GWR baseline model. Figure 4.18 illustrates the spatial autocorrelation test results for the standard residuals from the other-residential land model for a) OLS and b) GWR. Although the Koenker BP statistic is not significant, indicating that nonstationarity and heteroskedasticity are not present, a Getis and Ord's G_i test points to some significant clusters in the OLS residuals. Hot spots are present in the extreme west and east sides of the county, as shown in red in Figure 4.18(a). Cold spots are mainly present on the east side, as shown in blue, in Figure 4.18(b). Spatial autocorrelation disappears in the residuals from GWR for most, but not all, parcels in the county. As shown in yellow in Figure 4.18(b), some hot spots remain on the west side.

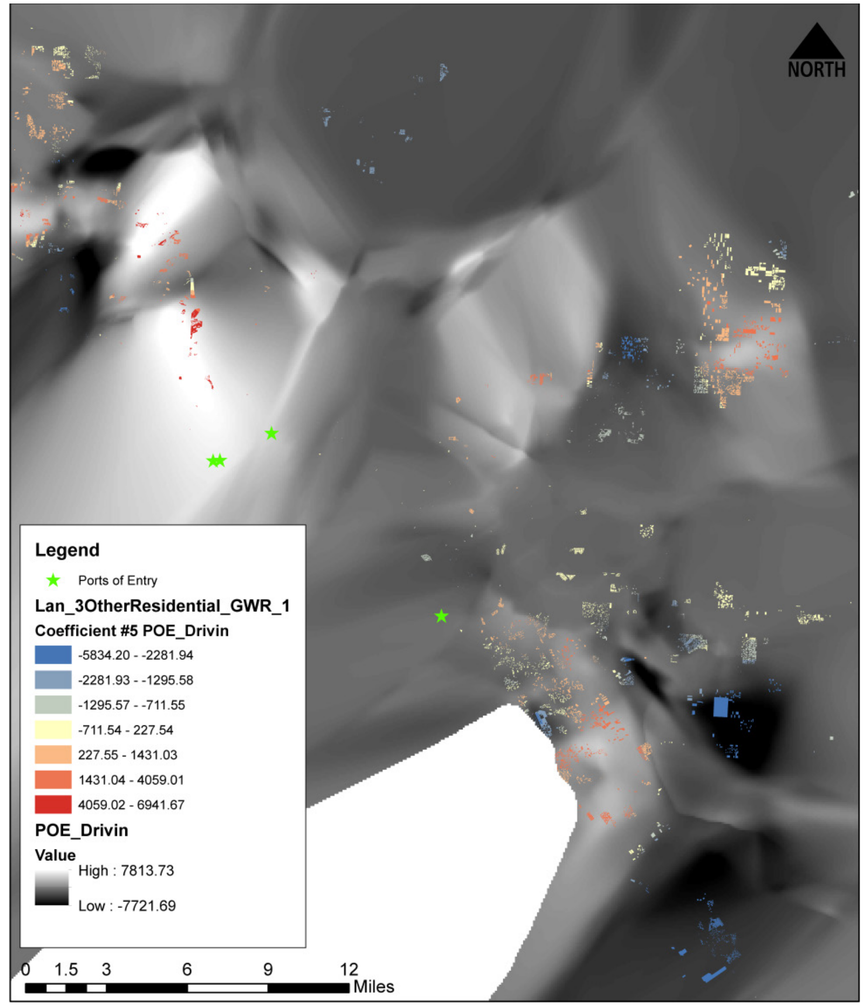


(a) *DistInterstate* (b) *DistFreeways*

Figure 4.17. Other-residential Land Value GWR Model Coefficients.

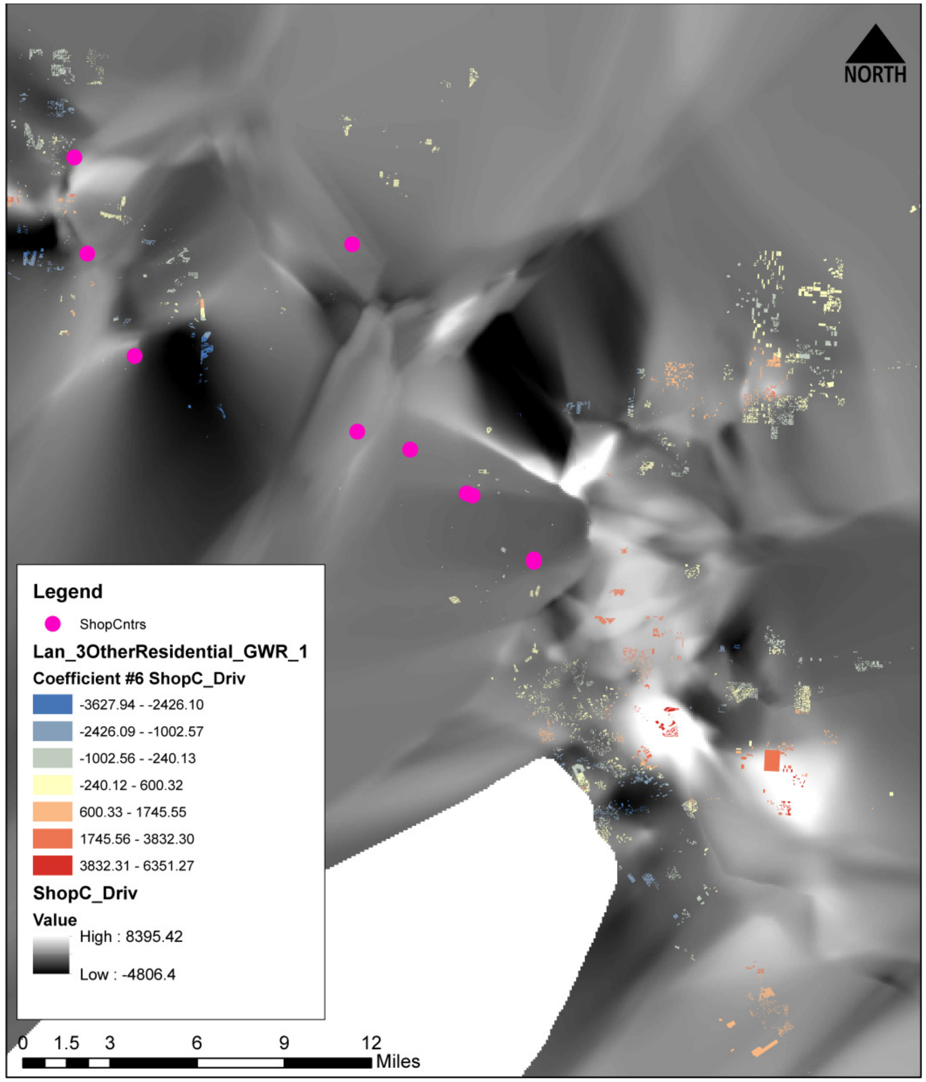


(c) *DistMajorArteries*



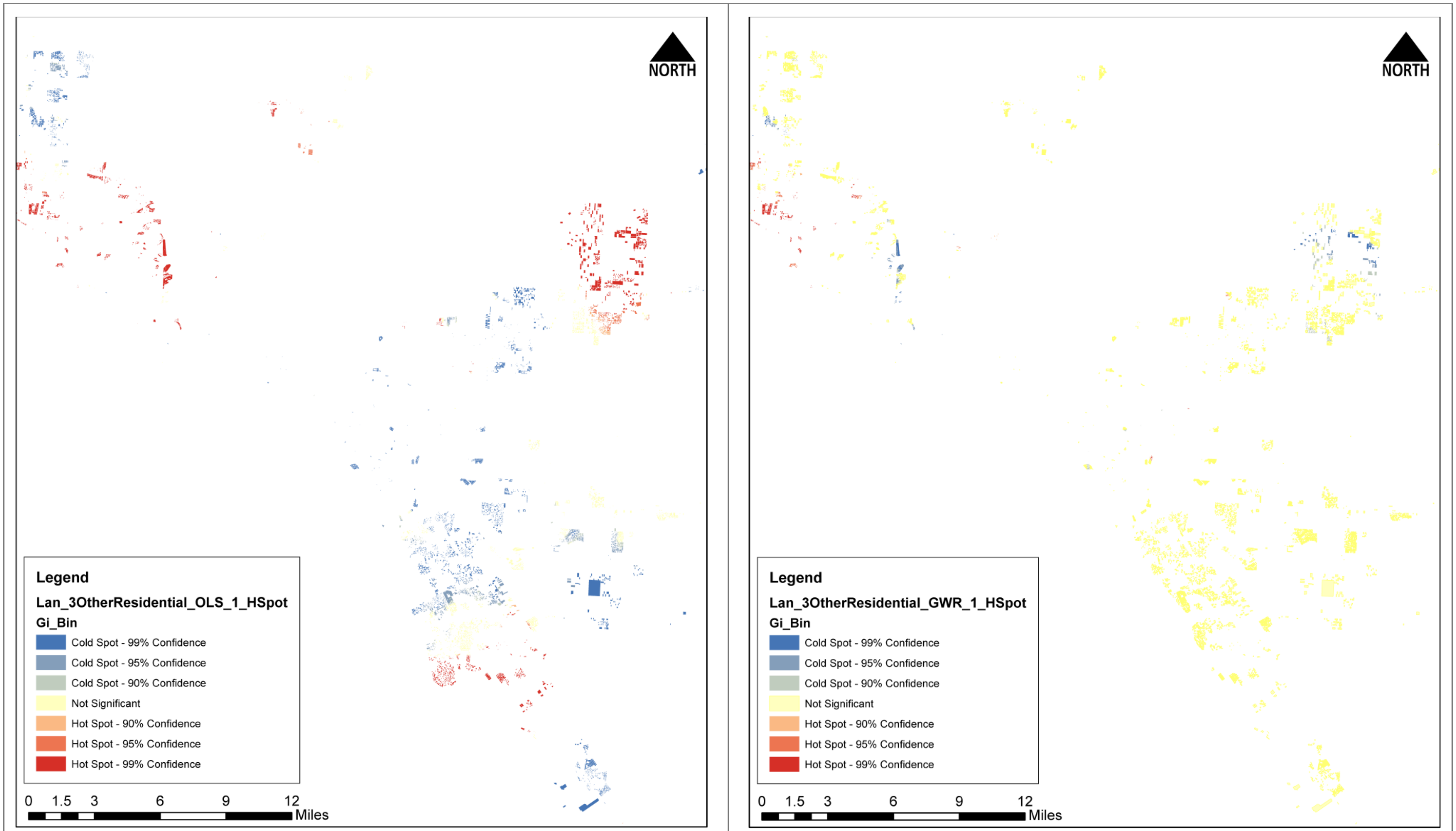
(d) *POE_DrivingTime*

Figure 4.17. Other-residential Land Value GWR Model Coefficients (continuation).



(e) *ShopC_DrivingTime*

Figure 4.17. Other-residential Land Value GWR Model Coefficients (continuation).



a) OLS Getis and Ord's G_i Test Results **b) GWR Getis and Ord's G_i Test Results**

Figure 4.18. Other-residential Land Value Model Spatial Autocorrelation Test Results.

4.4. COMMERCIAL

4.4.1. Commercial Total Value Model

The total value sample for commercial properties includes 105,611 observations (30.0% of the total population). The dependent variable is $TotValue_i$. Table 4.19 reports the OLS estimation results for the 15 independent variables plus the intercept term, from which 9 are statistically significant according to robust 95% confidence intervals. *TotValue* decreases $0.84 per foot as *DistInterstate* increases. *DistFreeways* and *DistMajorArteries* are not statistically significant at the 5% significance level. *POE_DrivingTime* indicates that *TotValue* decreases $2,058 for every minute it takes to drive from a commercial property to the nearest POE. *ShopC_DrivingTime* indicates that for every minute it takes to drive from a commercial property to its nearest shopping center, *TotValue* increases $1,755. The adjusted R^2 indicates that the total value model explains 53.9% of the variation in *TotValue*. The significant Jarque-Bera statistic indicates that the residuals are not normal. The Koenker BP statistic is significant indicating nonstationarity or heteroskedasticity. The Joint Wald Statistic indicates that the overall model is significant.

Table 4.19. Commercial—Total Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	-564784.98	32277.65	-17.50	0.00*	132987.38	-4.25	0.00*	------
ImpAge	839.79	265.40	3.16	0.00*	1078.38	0.78	0.44	4.55
Air	35897.51	11207.84	3.20	0.00*	29758.93	1.21	0.23	4.46
Depreciable	4195.10	271.59	15.45	0.00*	600.49	6.99	0.00*	4.20
LandAcres	-1244.54	363.34	-3.43	0.00*	3903.97	-0.32	0.75	1.05
ImpSize	15.56	0.05	314.76	0.00*	2.43	6.41	0.00*	1.23
Stories	165364.17	18434.53	8.97	0.00*	115085.77	1.44	0.15	12.00
Vacant	173080.29	22585.94	7.66	0.00*	121665.77	1.42	0.15	16.13
PopDens_CY	17.47	1.57	11.12	0.00*	6.26	2.79	0.01*	2.32
Unemp_CY	-175.99	42.99	-4.09	0.00*	65.62	-2.68	0.01*	2.49
PCI_CY	3.51	0.50	6.97	0.00*	1.76	2.00	0.05*	1.91
DistInterstate	-0.84	0.20	-4.12	0.00*	0.42	-1.97	0.05*	9.28
DistFreeways	-0.28	0.12	-2.25	0.02*	0.16	-1.81	0.07	2.07
DistMajorArteries	0.94	0.32	2.96	0.00*	0.58	1.63	0.10	7.19
POE_DrivingTime	-2058.95	553.99	-3.72	0.00*	1025.19	-2.01	0.04*	13.98
ShopC_DrivingTime	1755.97	420.24	4.18	0.00*	702.60	2.50	0.01*	8.65

Observations: 105611 AICc: 3083612

Multiple R-Squared: 0.539 Adjusted R-Squared: 0.539

Joint F-Statistic:	8226	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	6335	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	10205	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	390970357898	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

The GWR total value model yields 14,349 regression points with invertible matrices, which represent only 13.6% from the sample for commercial properties (in Table 4.20). Wang et al. (2012) report a similar outcome where less than 10% of the sample yields invertible Hessians. The mean local GWR coefficients for *DistInterstate* and *POE_DrivingTime* show signs that are consistent with the OLS parameters, but with greater magnitudes. As shown by Figure 4.19, the impacts of transportation infrastructure in *TotValue* are highly sensitive to location. As *DistInterstate* increases, *TotValue* decreases $3.62 per foot according to the mean. *DistInterstate* ranges from a negative $394 to a positive $296 per foot, as shown in Figure 4.19(a). *POE_DrivingTime* indicates that for every additional driving minute to the nearest POE, the *TotValue* of a commercial property decreases $22,500 on average. Coefficients from *POE_DrivingTime* range from a negative $588,108 to a positive $147,718 per minute, as shown in Figure 4.19(b). *ShopC_DrivingTime* indicates that *TotValue* decreases almost $9,937 on average. *ShopC_DrivingTime* ranges from a negative $602,337 to a positive $341,990 per minute, as shown in Figure 4.19(c). Results indicate that benefits from *ShopC_DrivingTime* are not capitalized by most commercial properties throughout the county, as shown in yellow, and some properties show negative coefficients, as shown by the parcels in blue, in Figure 4.19(c). This indicates that some commercial parcels benefit from proximity to shopping centers, a result that is at odds with the positive sign of the OLS coefficient.

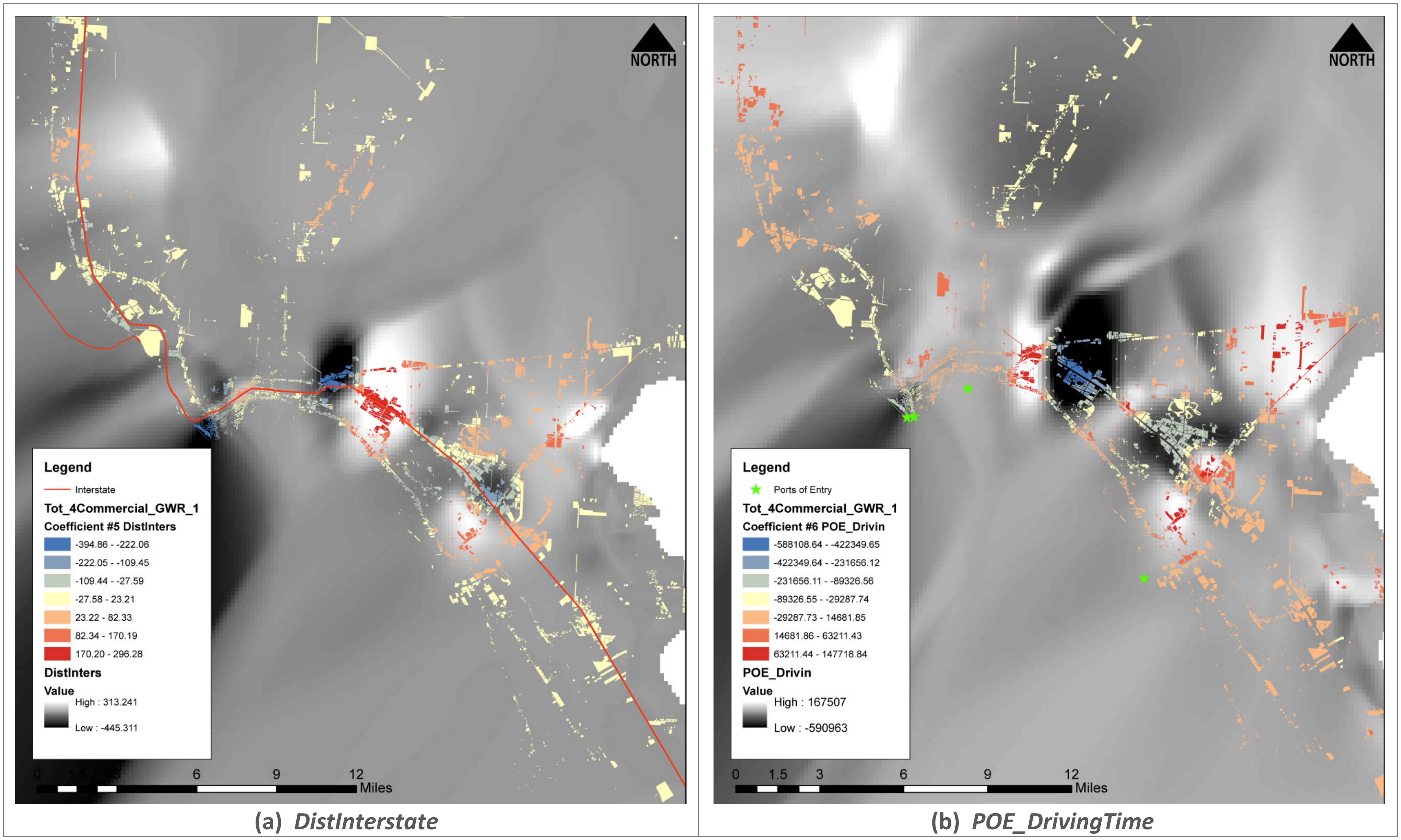
Properties with a positive premium from *POE_DrivingTime* are located on the west, central, and east parts of the county. Parcels with a positive premium are observed near the BOTA and Zaragoza POEs, but not near the downtown Paso Del Norte International Bridge. Many retail establishments in El Paso cater to Mexican shoppers by accepting pesos (Muñoz et al. 2011). Mexican shoppers and border commuters have to travel through the POEs. The further retailers are located away from the border, the less likely they are to accept pesos (Fullerton et al. 2009). In

the total value model for commercial, the a priori expectation is that parcels located closer to a POE have a positive premium. Although parcels with a premium are observed near BOTA and Zaragoza, the highest premia are located distant from the POEs in Figure 4.19(b). Further research is required to explore the underlying cause behind low or negative coefficients in the downtown area (e.g. exemptions, abatements, or similar agreements that reduce taxable values). A local newspaper cites the establishment of a Special Residential Revitalization District in the 1980s as the cause of a zoning issue in downtown with negative impacts on the property tax base (Mrkvicka, 2011). Alternatively, this could reflect a change in Mexican shoppers' preferences from older commercial areas in downtown to newer areas; for example, the Outlet Shoppes at El Paso (red cluster in the west) and Las Palmas Marketplace (red cluster in the east).

Table 4.20. Commercial—Total Value Model GWR Summary Statistics

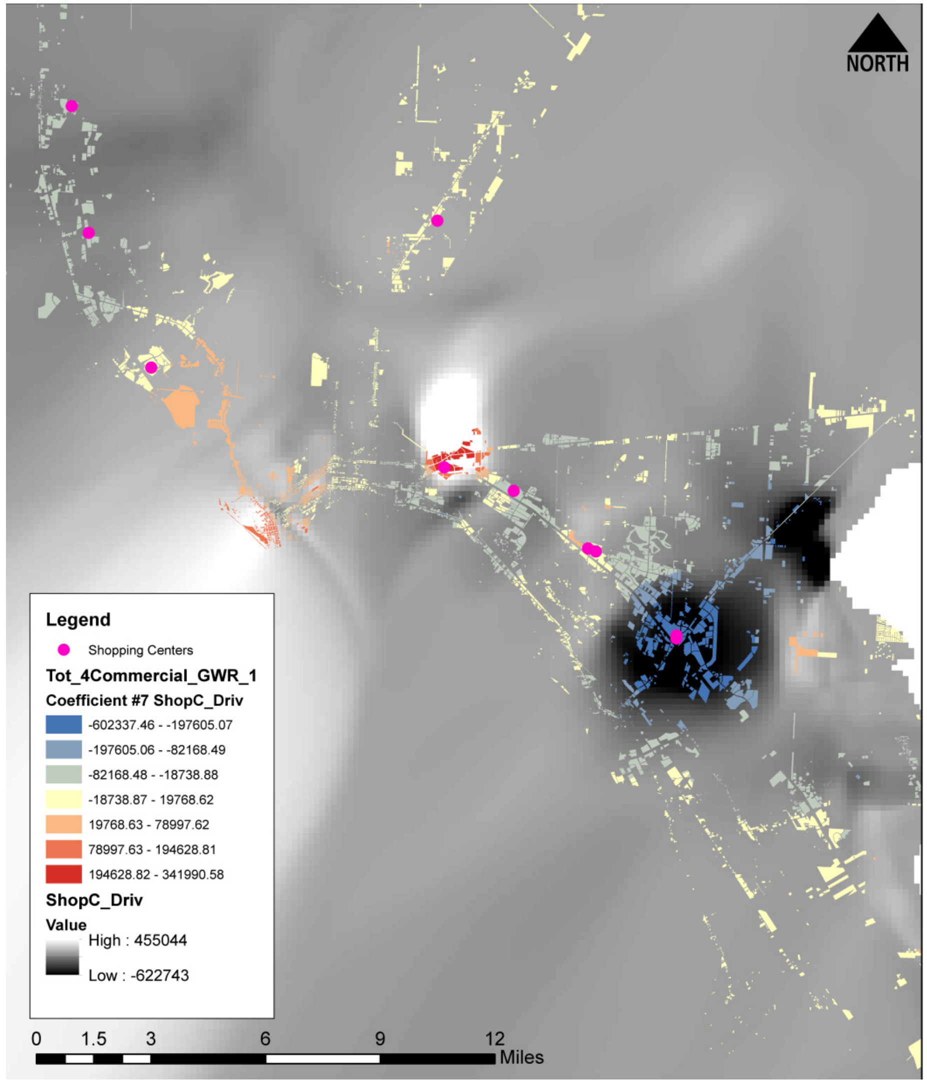
	Local coefficient estimates			Std. Error		
Variable	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
Intercept	-203002	-4746110	1923541	987715	233372	9390194
Depreciable	3667	-7326	35524	5810	1454	84675
ImpSize	14.5	-9.09	52.5	27.2	0.216	640
PopDens_CY	33.4	-131	2676	1308	7.34	67255
PCI_CY	8.50	-69.0	114	37.8	3.96	929
DistInterstate	-3.62	-394	296	32.3	2.80	185
POE_DrivingTime	-22500	-588108	147718	53013	8081	292829
ShopC_DrivingTime	-9937	-602337	341990	46957	10272	290086
Residual Squares:	1001990355825183	Sigma:	977037	R^2:	0.853	
Effective Number:	29.3	AICc:	32844	$AdjR^2$:	0.849	

The GWR global diagnostics show improvement over OLS for the AIC_c from 3,083,612 to 32,844 respectively, and $AdjR^2$ improved from 0.539 in OLS to 0.849 in the GWR baseline model. Figure 4.20(a) indicates that spatial autocorrelation is present among the residuals in the OLS model with hot spots predominantly on the west side and southeastern regions of the county, as shown in red. Cold spots dominate the outer west and east sides of the county, as shown in blue. Spatial autocorrelation is mostly absent from the GWR residuals, shown in yellow in Figure 20(b). However, a few cold spots remain on the east side of the county.



(a) *DistInterstate* (b) *POE_DrivingTime*

Figure 4.19. Commercial Total Value GWR Model Coefficients.



(c) *ShopC_DrivingTime*

Figure 4.19. Commercial Total Value GWR Model Coefficients (continuation).

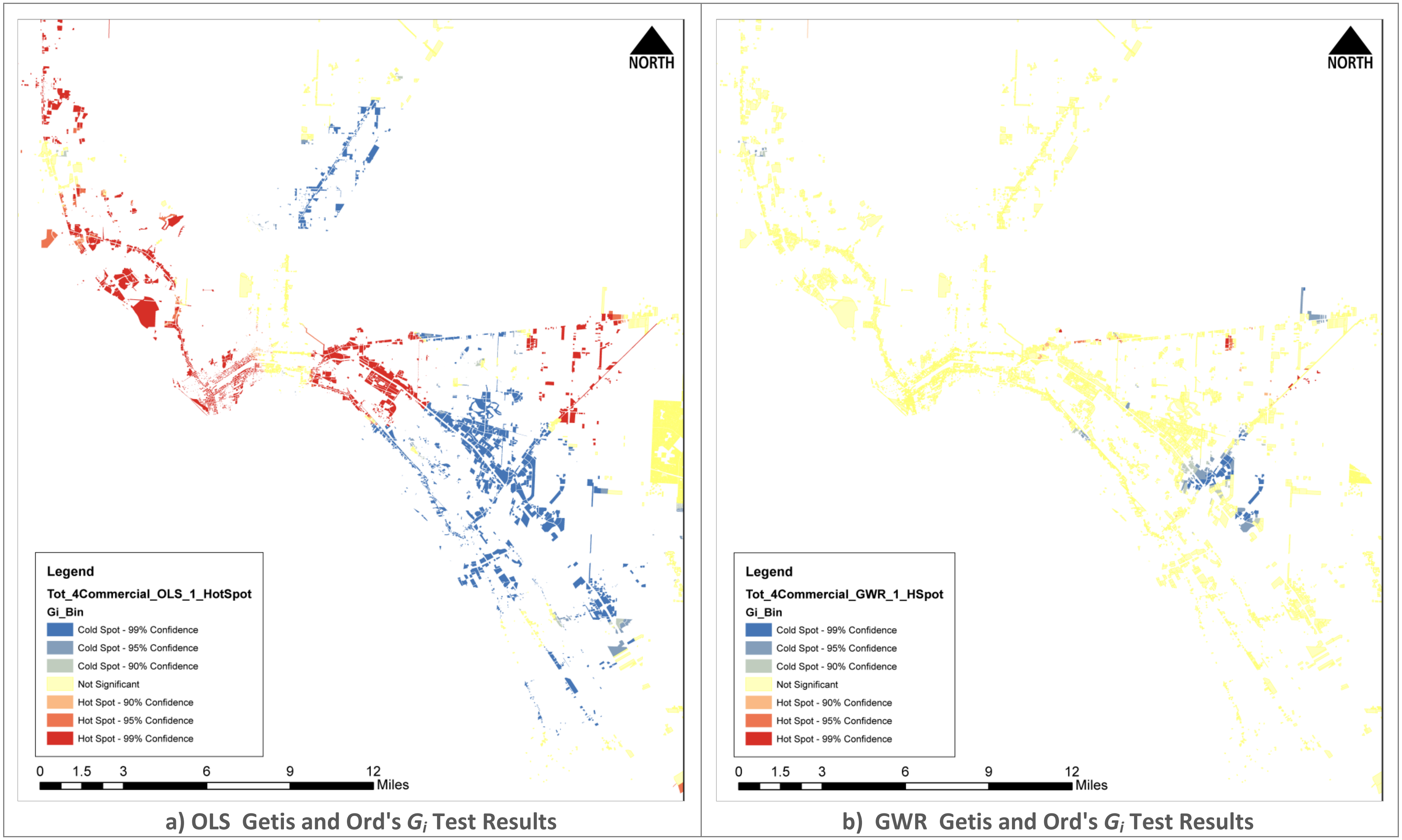


Figure 4.20. Commercial Total Value Model Spatial Autocorrelation Test Results.

4.4.2. Commercial Improvement Value Model

The improvement value sample for commercial properties contains 105,611 observations (30.0% of the total population). The dependent variable is *ImpValue*$_i$. Table 4.21 reports OLS estimation results for the 17 independent variables plus the intercept term, 7 of which are statistically significant according to robust 95% confidence intervals. In this model, *Mp35003a_B, DistInterstate, DistFreeways, and DistMajorArteries* are not significant. *POE_DrivingTime* indicates that *ImpValue* decreases $2,260 for every additional minute it takes to drive from a commercial property to the nearest POE. The impact from accessibility to a POE for the *ImpValue* is very similar the impact found in *TotValue*. *ShopC_DrivingTime* indicates that for every minute it takes to drive from a commercial property to its nearest shopping center, *ImpValue* increases $1,680. The impact from accessibility to a shopping center for the *ImpValue* is very similar to the impact estimated for *TotValue*. The adjusted R^2 indicates that the improvement value model explains only 4.4% of the variation in *TotValue*. The significant Jarque-Bera statistic indicates that residuals are not normal. The Koenker BP statistic is significant, indicating nonstationarity or heteroskedasticity. The Joint Wald Statistic indicates that the overall model is significant.

Table 4.21. Commercial—Improvement Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	-407101.72	25081.87	-16.23	0.00*	67941.03	-5.99	0.00*	-----
ImpAge	1106.54	228.84	4.84	0.00*	785.43	1.41	0.16	4.68
Air	1709.32	9376.45	0.18	0.86	27240.40	0.06	0.95	2.38
Depreciable	4316.60	227.22	19.00	0.00*	583.78	7.39	0.00*	4.06
LandAcres	-2835.19	308.95	-9.18	0.00*	2986.61	-0.95	0.34	1.05
ImpSize	11.16	0.04	265.47	0.00*	2.17	5.15	0.00*	1.23
Stories	47255.32	9941.65	4.75	0.00*	98657.03	0.48	0.63	4.83
PopDens_CY	10.26	1.36	7.53	0.00*	5.49	1.87	0.06	2.41
Renter_CY	22.55	20.71	1.09	0.28	57.19	0.39	0.69	3.38
Vacant_CY	958.33	83.66	11.46	0.00*	451.95	2.12	0.03*	10.97
Unemp_CY	-201.24	49.87	-4.04	0.00*	80.48	-2.50	0.01*	4.64
PCI_CY	-1.06	0.46	-2.32	0.02*	2.25	-0.47	0.64	2.19
Mp35003a_B	-669.22	66.95	-10.00	0.00*	359.56	-1.86	0.06	6.85
DistInterstate	-0.09	0.18	-0.47	0.64	0.44	-0.20	0.84	10.17
DistFreeways	0.56	0.12	4.80	0.00*	0.40	1.39	0.17	2.47
DistMajorArteries	0.48	0.28	1.73	0.08	0.43	1.12	0.26	7.63
POE_DrivingTime	-2263.33	512.75	-4.41	0.00*	809.37	-2.80	0.01*	16.56
ShopC_DrivingTime	1676.92	373.74	4.49	0.00*	634.62	2.64	0.01*	9.46

Observations:	105611	AICc:	3049392
Multiple R-Squared:	0.445	Adjusted R-Squared:	0.445
Joint F-Statistic:	4984	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	3574	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	8533	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	584084025438	Prob(>chi-squared), (2) degrees of freedom:	0.00*

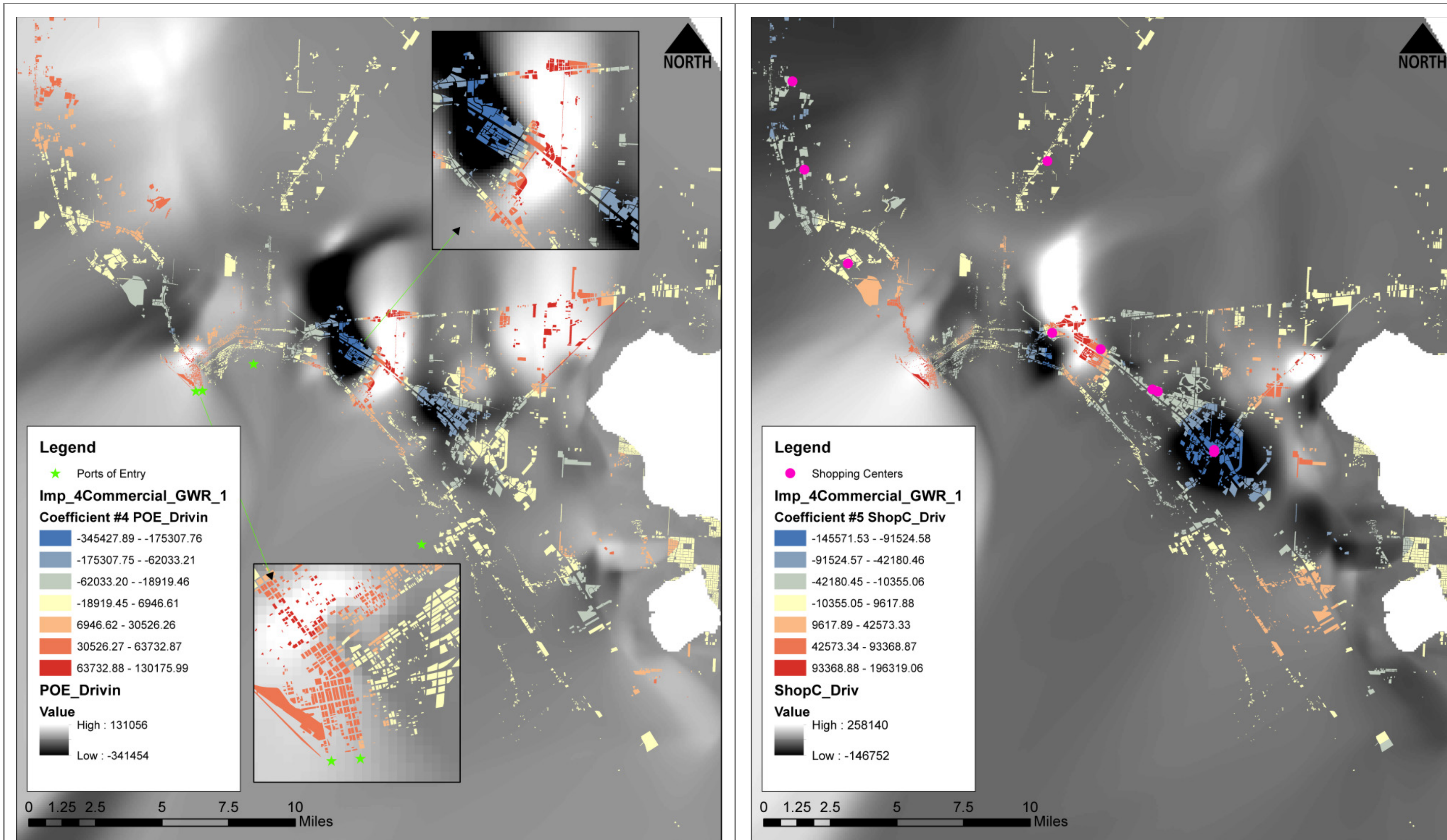
*Statistically significant probabilities have an asterisk next to them.

The GWR improvement value model yields 16,232 regression points with invertible matrices; only 15.4% of the commercial sample data (see Table 4.22). The mean local coefficient for *POE_DrivingTime* shows the same sign as its OLS counterpart and a very close magnitude. The mean values of *ShopC_DrivingTime* show signs contrary to their OLS estimation. Figure 4.21 reveals that improvements located in parcels near the downtown area show positive coefficients, in red, indicating that benefits from the proximity to a POE are capitalized mainly by the improvement instead of the land of commercial parcels; contrary to single-family in similar locations, where the land showed higher premia than the improvement. *POE_DrivingTime* indicates that *ImpValue* decreases almost $2,577 per minute on average. *POE_DrivingTime* ranges from a negative $345,427 to a positive $130,175 per minute depending on their location, as shown in Figure 4.21(a). *ShopC_DrivingTime* indicates that for every additional driving minute to the nearest shopping center, the *ImpValue* decreases almost $3,177 on average. *ShopC_DrivingTime* ranges from a negative $146,530 to a positive $196,319 per minute, as shown in Figure 4.21(b). A significant number of improvements with a high premium are located distant from the POEs, in the west and east sides of the county consistent with the findings in the total value model. Parcels with a positive *ShopC_DrivingTime* premium are near downtown and the malls in the central area.

Table 4.22. Commercial—Improvement Value Model GWR Summary Statistics

	Local coefficient estimates			Std. Error		
Variable	Mean	Min	Max	Mean	Min	Max
Intercept	-223067	-3600630	1604137	1517231	226186	12284376
Depreciable	3024	-4858	31269	10653	1970	120744
ImpSize	11.1	-4.07	44.9	52.7	0.293	1845
Unemp_CY	449	-4884	7188	3283	744	233925
POE_DrivingTime	-2577	-345427	130175	72215	10230	401251
ShopC_DrivingTime	-3177	-146530	196319	59642	11284	398829
Residual Squares:	12085300606493702	Sigma:	1326669	R^2: 0.659		
Effective Number:	126	AICc:	217096	AdjR^2: 0.652		

The GWR global diagnostics show improvement over OLS for the AIC_c which drops from 3,049,392 to 217,096, and $AdjR^2$ improves from 0.445 in OLS to 0.652 in the GWR baseline model. Figure 4.22 illustrates the spatial autocorrelation test results on the standard residuals from the other-residential total value model for a) OLS and b) GWR. Results indicate that spatial autocorrelation is a problem in the residuals from the OLS model. Spatial autocorrelation disappears from the majority of the GWR residuals, but some hot spots remain in the east side of the county.



(a) *DistInterstate* (b) *POE_DrivingTime*

Figure 4.21. Commercial Improvement Value GWR Model Coefficients.

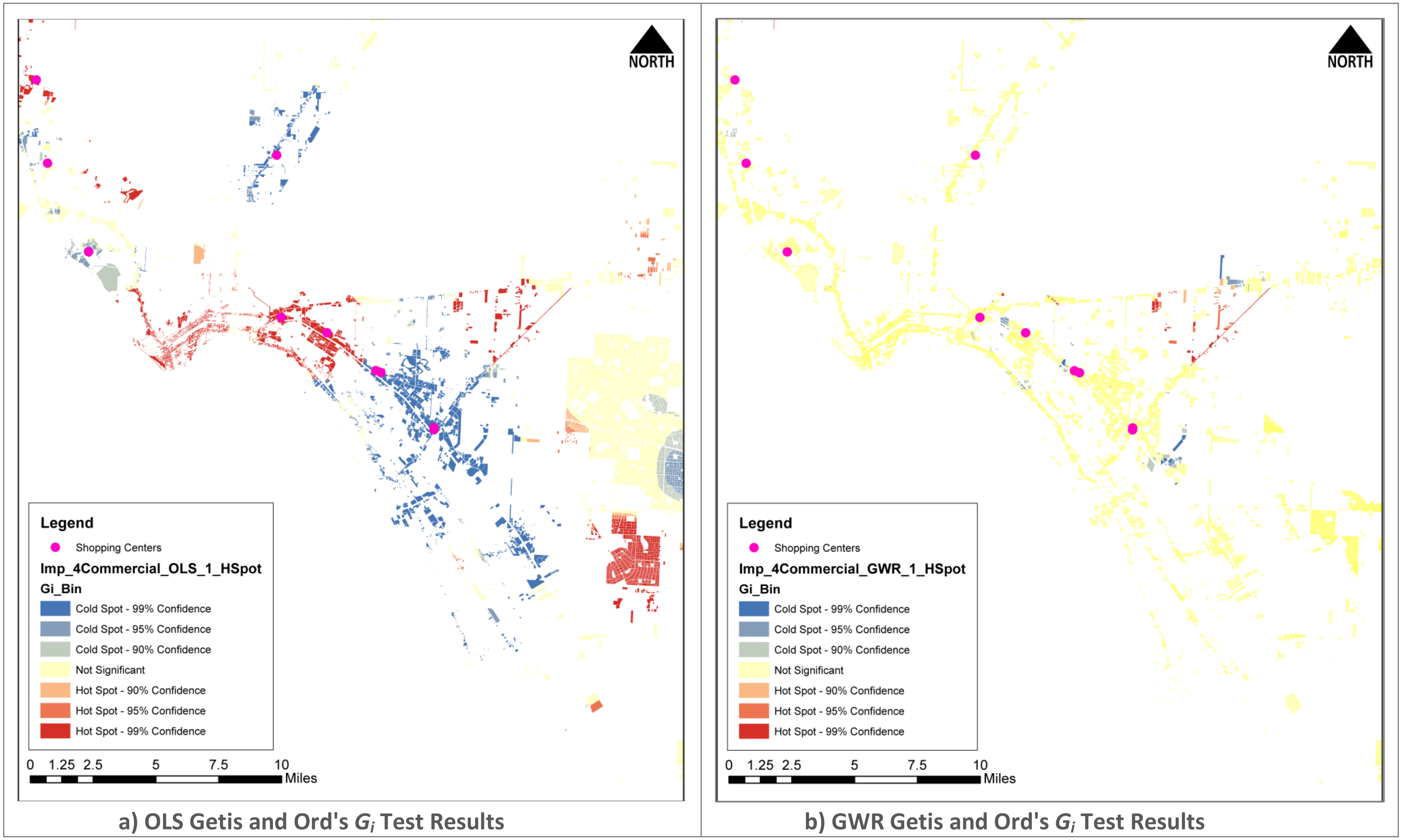


Figure 4.22. Commercial Improvement Value Model Spatial Autocorrelation Test Results.

4.4.3. Commercial Land Value Model

The land value sample for commercial properties consists of 105,611 observations (30.0% of the total population). The dependent variable is *LandValue*$_i$. Table 4.23 presents the results for the 7 independent variables plus the intercept term, which all are statistically significant. *LandValue* decreases $1.34 per foot as *DistInterstate* increases. Similarly, *DistFreeways* indicates a decrease in *LandValue* of $1.20 per foot. *DistMajorArteries* indicates an increase in *LandValue* of $4.84 per foot. *POE_DrivingTime* indicates that *LandValue* decreases $5,110 for every additional minute a commercial property is located away from the nearest POE. This is consistent with the findings in *TotValue* and *ImpValue*. *ShopC_DrivingTime* indicates that for every driving minute a commercial property is located away from its nearest shopping center, *LandValue* decreases $1,885. The impact from accessibility to a shopping center for *LandValue* is contrary to the findings in *TotValue* and *ImpValue*. The land value model explains 10.4% of the variation in the dependent variable. The residuals are not normal. The Koenker BP statistic is significant suggesting nonstationarity or heteroskedasticity. The Joint Wald Statistic indicates that the overall model is significant.

Table 4.23. Commercial—Land Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	292863.10	3767.08	77.74	0.00*	10536.15	27.80	0.00*	------
$ImpAge^2$	-11.17	0.85	-13.16	0.00*	1.38	8.10	0.00*	1.48
LandAcres	8239.21	147.54	55.84	0.00*	3264.51	2.52	0.01*	1.01
DistInterstate	-1.34	0.07	-17.92	0.00*	0.09	14.70	0.00*	7.31
DistFreeways	-1.20	0.04	-27.41	0.00*	0.05	25.99	0.00*	1.49
DistMajorArteries	4.84	0.11	43.59	0.00*	0.19	24.88	0.00*	5.09
POE_DrivingTime	-5110.57	168.00	-30.42	0.00*	197.55	25.87	0.00*	7.48
ShopC_DrivingTime	-1885.79	140.33	-13.44	0.00*	147.90	12.75	0.00*	5.62

Observations:	105611	AICc:	2897570
Multiple R-Squared:	0.104	Adjusted R-Squared:	0.104
Joint F-Statistic:	1751	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	1717	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	1561	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	72690700138	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

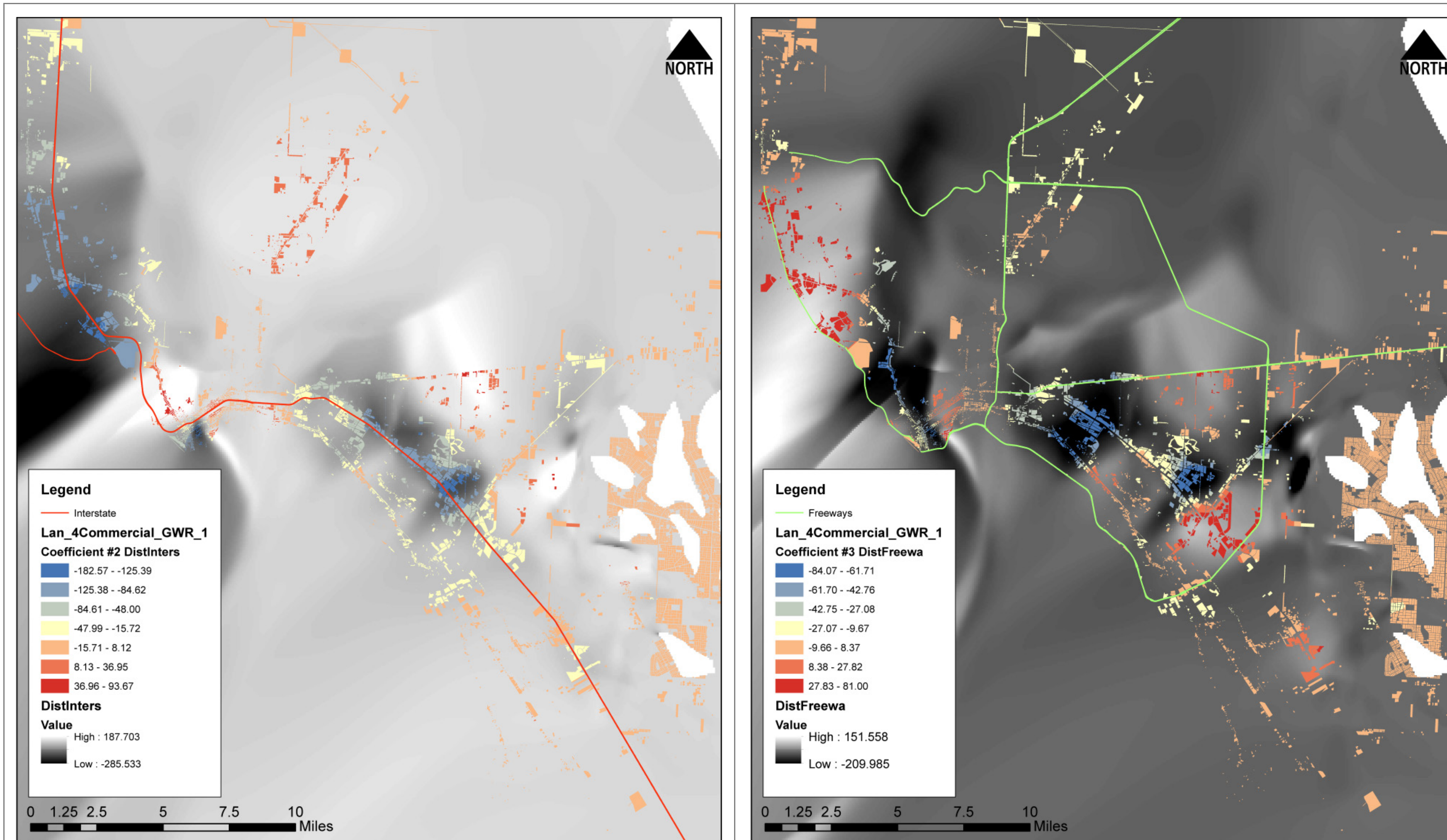
The GWR land value model yields 34,698 regression points with invertible matrices, which represent 32.9% from the commercial sample (Table 4.24). The mean values of all the local coefficients show signs opposite to OLS. As shown in red and orange by Figure 4.23, *DistInterstate* is higher for the land located in the north and central parts of the county, and for a significant amount of parcels located in the eastern and southeastern parts of the county. As *DistInterstate* increases, *LandValue* decreases $9.60 per foot at the mean. Local coefficients for *DistInterstate* range from a negative $182 to a positive $93.60 per foot depending on their location, as shown in Figure 4.23(a). As *DistFreeways* increases, *LandValue* decreases $2.70 per foot at the mean. Local coefficients for *DistFreeways* range from a negative $84.00 to a positive $85.80 per foot, as shown in Figure 4.23(b). *DistMajorArteries* indicates that *LandValue* decreases $20.20 per foot at the mean. Coefficients from *DistMajorArteries* range from a negative $334 to an increase of $126 per foot, as shown in Figure 4.23(c). *POE_DrivingTime* indicates that for every additional driving minute to the nearest POE, the *LandValue* decreases almost $3,021 on average. Coefficients from *POE_DrivingTime* range from a negative $129,986 to a positive $149,563 per minute, as shown in Figure 4.23(d). A premia for *DistFreeways* is visible almost throughout all commercial land. *POE_DrivingTime* suggests that the premia is capitalized by the improvement rather than the land near downtown. Parcels along the interstate exhibit premia for accessibility to the nearest POE.

Table 4.24. Commercial—Land Value Model GWR Summary Statistics

	Local coefficient estimates			Std. Error		
Variable	Mean	Min	Max	Mean	Min	Max
Intercept	132041	-1112420	2250256	1828481	78419	7641128
LandAcres	49707	-160	1088279	53121	614	220355
DistInterstate	-9.61	-182	93.6	41.3	2.20	343
DistFreeways	-2.70	-84.0	85.8	37.2	1.87	208
DistMajorArteries	-20.2	-334	126	54.3	3.59	310
POE_DrivingTime	-3021	-129986	149563	44153	6083	137962
Residual Squares:	1992943310671888	Sigma:	546548	R^2: 0.500		
Effective Number:	111	AICc:	198541	$AdjR^2$: 0.492		

The GWR global diagnostics show improvement relative to OLS for the AIC_c from 2,897,570 to 198,541 respectively, and $AdjR^2$ improved from 0.104 in OLS to 0.492 in the GWR. Figure 4.24 illustrates the spatial autocorrelation test on the standard residuals from the commercial land

value model for a) OLS and b) GWR. Results indicate that spatial autocorrelation is a problem for the OLS residuals. Spatial autocorrelation disappears in the residuals from GWR for most parcels, as shown in yellow. However, hot and cold spots remain an issue for a significant number of parcels, as shown in red and blue respectively.



(a) *DistInterstate* (b) *DistFreeways*

Figure 4.23. Commercial Land Value GWR Model Coefficients.

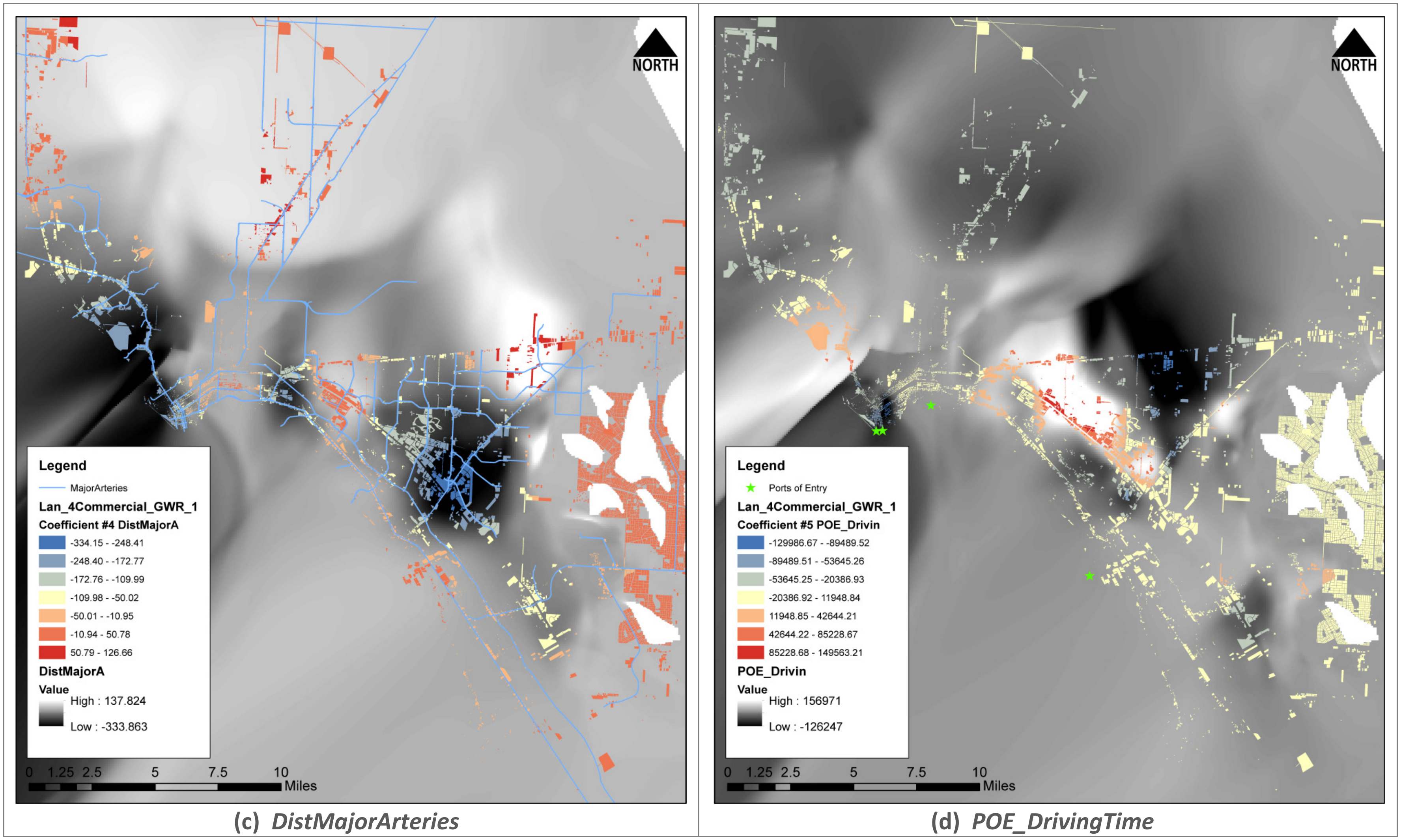
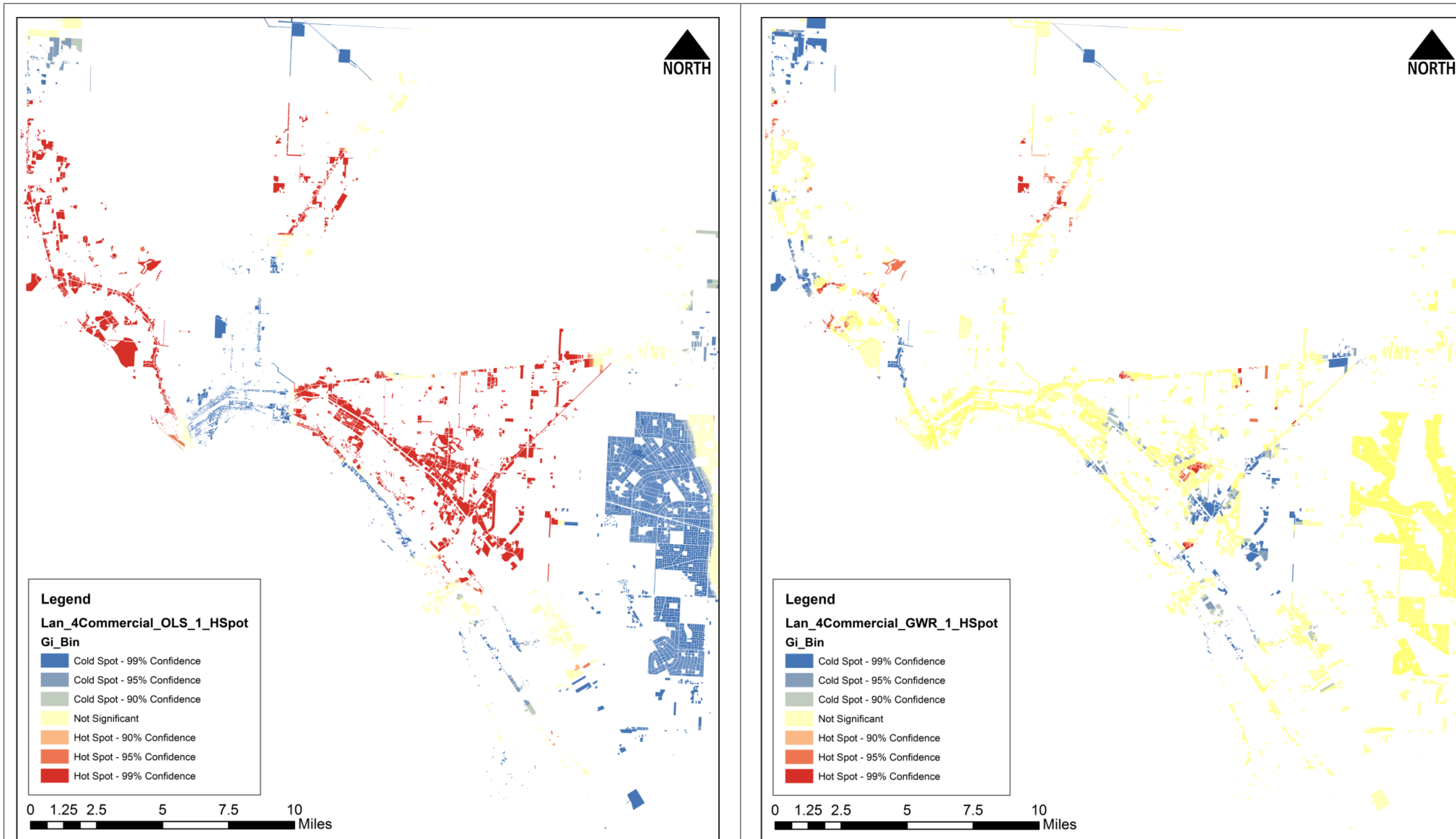


Figure 4.23. Commercial Land Value GWR Model Coefficients (continuation).



a) OLS Getis and Ord's G_i Test Results b) GWR Getis and Ord's G_i Test Results

Figure 4.24. Commercial Improvement Value Model Spatial Autocorrelation Test Results.

4.5. INDUSTRIAL

4.5.1. Industrial Total Value Model

The total value sample contains 162 data points (0.1% of the total population). The dependent variable is the *TotValue* for industrial units. Table 4.25 presents the results for the 11 independent variables plus the intercept term; none are statistically significant according to robust 95% confidence intervals. Adjusted R^2 indicates that the total value model explains 29.6% of the variation in the dependent variable. The value of the Jarque-Bera statistic indicates that the residuals are not normally distributed. The Koenker BP statistic is significant indicating issues with nonstationarity or heteroskedasticity; hence, regular t-statistics and probabilities are not trustworthy, only their robust estimates. The Joint Wald Statistic indicates that the overall model is significant. Because none of the explanatory variables are significant in the OLS equation, the GWR results are irrelevant, and not presented.

Table 4.25. Industrial—Total Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	132747303.06	20078468.93	6.61	0.00*	93565962.96	1.42	0.16	--------
ImpAge	562058.69	159579.14	3.52	0.00*	404570.88	1.39	0.17	3.30
Yrs_SRemod	1583474.63	339626.53	4.66	0.00*	1140915.26	1.39	0.17	4.87
Depreciable	1010494.44	175696.18	5.75	0.00*	732963.09	1.38	0.17	5.21
LandAcres	329696.70	81390.56	4.05	0.00*	197717.23	1.67	0.10	1.22
ImpSize	1.52	7.58	0.20	0.84	6.35	0.24	0.81	1.22
Vacant	27330626.38	8657605.94	3.16	0.00*	17651524.72	1.55	0.12	1.80
DistInterstate	102.20	206.96	0.49	0.62	113.16	0.90	0.37	1.49
DistFreeways	185.75	196.08	0.95	0.34	179.15	1.04	0.30	1.54
DistMajorArteries	619.60	1490.04	0.42	0.68	689.12	0.90	0.37	1.18
POE_DrivingTime	760709.96	436243.00	1.74	0.08	512253.75	1.49	0.14	2.11
ShopC_DrivingTime	524025.85	451431.41	1.16	0.25	439328.56	1.19	0.23	1.71

Observations:	162	AICc:	5979
Multiple R-Squared:	0.344	Adjusted R-Squared:	0.296
Joint F-Statistic:	7	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	21	Prob(>chi-squared), (21) degrees of freedom:	0.03*
Koenker (BP) Statistic:	53	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	39701	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

4.5.2. Industrial Improvement Value Model

The industrial improvement value sample includes 162 data points (0.1% of the total population). The dependent variable is the *ImpValue* for industrial parcels. Table 4.26 summarizes OLS results for the 17 independent variables plus the intercept term. None are statistically significant according to robust 95% confidence intervals. Adjusted R^2 indicates that the improvement value model explains 29.6% of the variation in the dependent variable. The value of the Jarque-Bera statistic indicates that residuals are not normal. The Koenker BP statistic is significant indicating issues with nonstationarity or heteroskedasticity; hence, regular t-statistics and probabilities are not trustworthy and robust counterparts should be used. The Joint Wald Statistic indicates that the overall model is significant. Because none of the OLS parameters are significant, the GWR results are irrelevant and not reported.

Table 4.26. Industrial—Improvement Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	49794957.47	16317656.58	3.05	0.00*	41191406.20	1.21	0.23	----
ImpAge	712356.20	181858.17	3.92	0.00*	551755.00	1.29	0.20	3.48
Air	6956524.33	4763788.66	1.46	0.15	5586370.27	1.25	0.22	1.31
Depreciable	443123.93	138022.45	3.21	0.00*	370823.21	1.19	0.23	2.61
LandAcres	460353.27	92562.65	4.97	0.00*	300553.45	1.53	0.13	1.29
ImpSize	6.52	8.91	0.73	0.47	9.25	0.71	0.48	1.37
Stories	19609667.29	9940717.79	1.97	0.05	13743052.41	1.43	0.16	2.10
PopDens_CY	151.72	1716.64	0.09	0.93	656.68	0.23	0.82	1.85
Renter_CY	3657.80	16690.20	0.22	0.83	5808.33	0.63	0.53	1.83
Vacant_CY	94016.43	161482.43	0.58	0.56	90838.45	1.03	0.30	2.35
Unemp_CY	57581.66	68702.85	0.84	0.40	64215.07	0.90	0.37	2.85
PCI_CY	27.00	560.10	0.05	0.96	319.82	0.08	0.93	3.48
Mp35003a_B	31252.79	86329.28	0.36	0.72	58481.95	0.53	0.59	5.59
DistInterstate	104.36	275.75	0.38	0.71	140.92	0.74	0.46	2.15
DistFreeways	351.98	245.75	1.43	0.15	275.27	1.28	0.20	1.96
DistMajorArteries	732.45	1789.98	0.41	0.68	1013.05	0.72	0.47	1.39
POE_DrivingTime	1190078.77	548141.28	2.17	0.03*	846809.32	1.41	0.16	2.70
ShopC_DrivingTime	131541.43	559038.53	0.24	0.81	305874.18	0.43	0.67	2.14

Observations:	162	AICc:	6021
Multiple R-Squared:	0.277	Adjusted R-Squared:	0.192
Joint F-Statistic:	3	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	19	Prob(>chi-squared), (21) degrees of freedom:	0.32
Koenker (BP) Statistic:	39	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	61297	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

4.5.3. Industrial Land Value Model

The land value industrial properties sample consists of 162 observations (0.1% of the total population). The dependent variable is *LandValue*$_i$. Table 4.27 presents the results for the 6 independent variables plus the intercept term, from which 3 coefficients are statistically significant according to robust 95% confidence intervals. *LandValue* increases $96.20 per foot as *DistMajorArteries* increases. *ShopC_DrivingTime* indicates that for every minute it takes to drive from a commercial property to its nearest shopping center, *LandValue* increases $21,627. Adjusted R^2 indicates that the land value model explains 45.7% of the variation. The value of the Jarque-Bera statistic indicates that residuals are not normally distributed. The Koenker BP statistic is significant indicating nonstationarity or heteroskedasticity. The Joint Wald Statistic indicates that the overall model is significant.

Table 4.27. Industrial—Land Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	357281.82	91742.23	3.89	0.00*	98022.44	3.64	0.00*	-----
LandAcres	15993.58	1411.57	11.33	0.00*	2480.03	6.45	0.00*	1.07
DistInterstate	1.35	3.76	0.36	0.72	2.88	0.47	0.64	1.43
DistFreeways	0.90	3.59	0.25	0.80	3.43	0.26	0.79	1.50
DistMajorArteries	96.23	26.77	3.60	0.00*	35.43	2.72	0.01*	1.11
POE_DrivingTime	2455.40	7383.87	0.33	0.74	7321.12	0.34	0.74	1.76
ShopC_DrivingTime	21627.67	7943.68	2.72	0.01*	9719.32	2.23	0.03*	1.54

Observations:	162	AICc:	4680
Multiple R-Squared:	0.477	Adjusted R-Squared:	0.457
Joint F-Statistic:	24	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	64	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	24	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	224	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

The GWR land value model yields 162 regression points with invertible matrices, all from the industrial sample (see Table 4.28). As shown by Figure 4.25, the premium for *DistMajorArteries* is high for the land of parcels located in the west, and is moderate or non-existent for parcels in the east side. *DistMajorArteries* indicates that *LandValue* increases $86.67 per foot at the mean. Local coefficients for *DistMajorArteries* range from a positive $39.31 to a

positive \$142 per foot depending on their location, as shown in Figure 4.25(a). *ShopC_DrivingTime* indicates that for every additional driving minute to the nearest POE, the *LandValue* decreases almost \$22,174 on average. Coefficients from *ShopC_DrivingTime* range from a negative \$30,924 to a negative \$14,650 per minute depending on their location, as shown in Figure 4.25(b). The mean values of all the local coefficients show opposite signs to those of the OLS counterparts. *ShopC_DrivingTime* indicates a premia capitalized by the land of industrial parcels located in the extreme east side of the county.

Table 4.28. Industrial—Land Value Model GWR Summary Statistics

	Local coefficient estimates			Std. Error		
Variable	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
Intercept	330401	287576	405909	96554	90545	105037
LandAcres	16025	13950	17079	1375	1352	1415
DistMajorArteries	86.6	39.3	142	28.9	27.5	32.0
ShopC_DrivingTime	-22174	-30924	-14650	6969	6533	7301
Residual Squares:	27264864004181	Sigma:	418844	R^2:	0.526	
Effective Number:	6.58	AICc:	4661	$AdjR^2$:	0.509	

The GWR global diagnostics show improvement relative to OLS for the AIC_c from 4,680 to 4,661 respectively, and $AdjR^2$ improved from 0.457 in OLS to 0.509 in the GWR baseline model. Figure 4.26 illustrates the spatial autocorrelation test results on the standard residuals from the commercial land value model for a) OLS and b) GWR. A small Koenker BP statistic indicates spatial nonstationarity or heteroskedasticity for the OLS residuals; this is confirmed by the results from the *Getis and Ord's Gi* Test, as shown in Figure 4.26(a). Spatial autocorrelation is mostly absent from the GWR residuals; however, a few cold spots remain on the east side of the county, as shown in Figure 4.26(b).

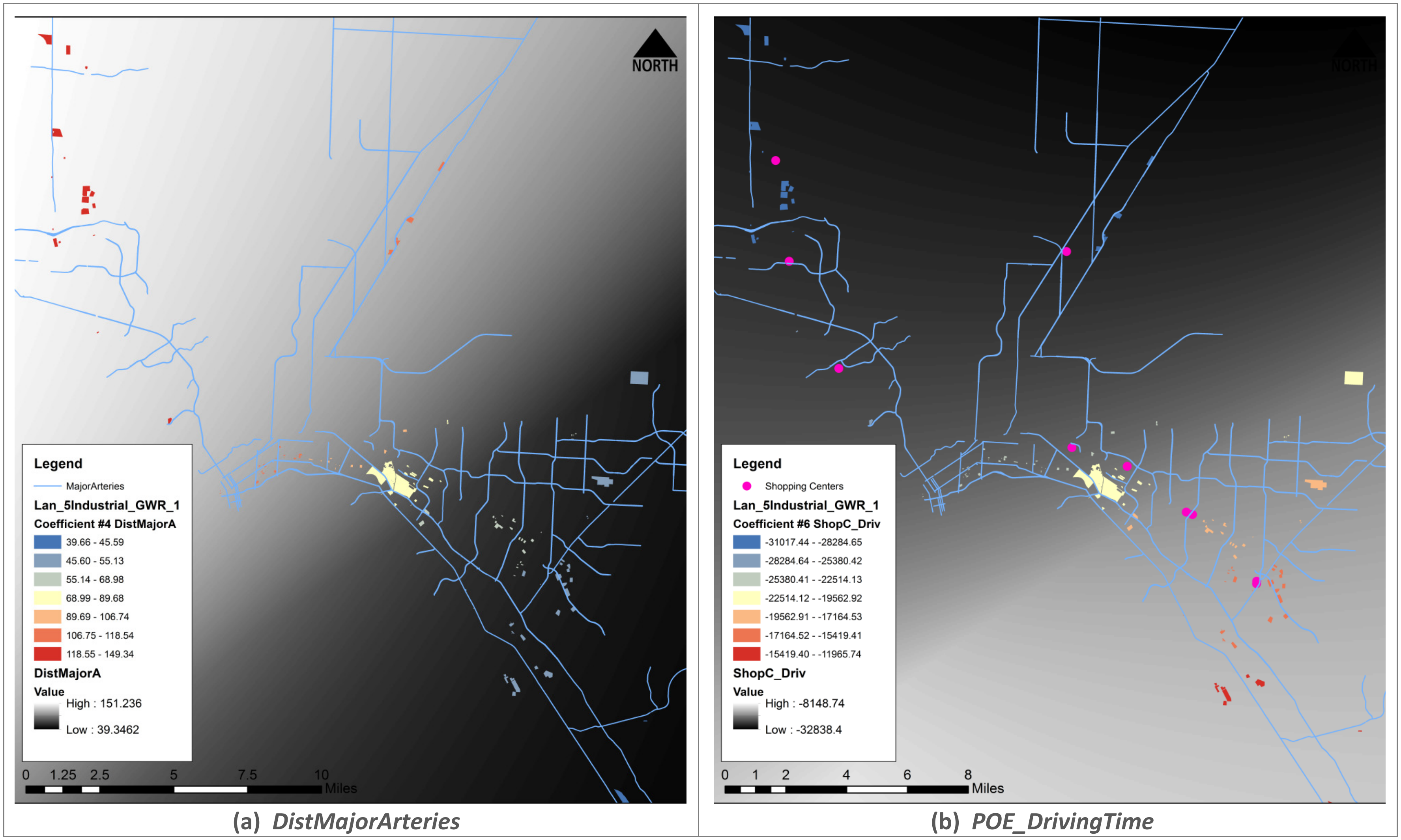
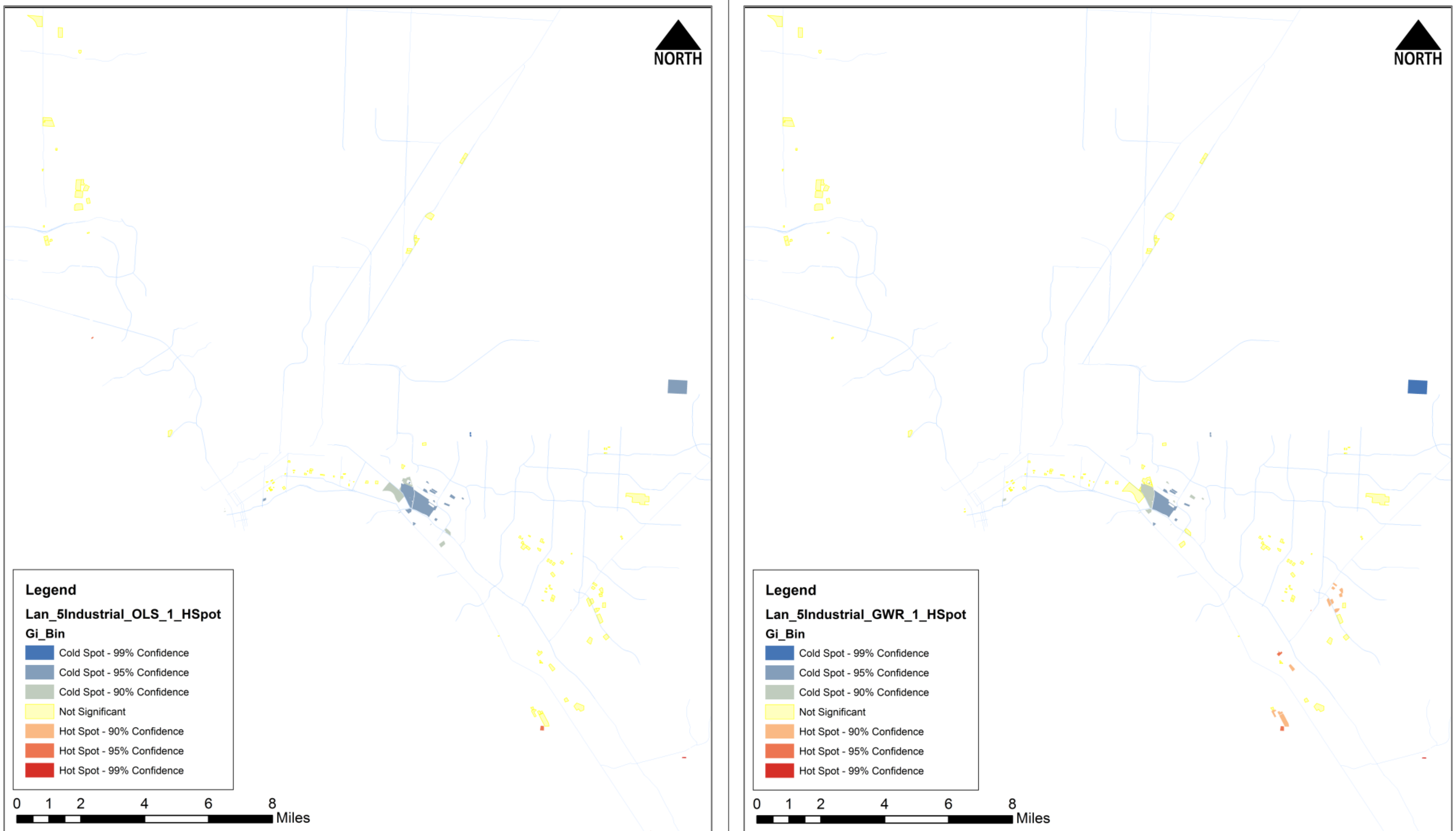


Figure 4.25. Industrial Land Value GWR Model Coefficients.



a) OLS Getis and Ord's G_i Test Results

b) GWR Getis and Ord's G_i Test Results

Figure 4.26. Industrial Improvement Value Model Spatial Autocorrelation Test Results.

4.6. Qualifying Open Space

4.6.1. Qualifying Open Space Total Value Model

The total value sample for qualifying open space contains 9,739 observations (2.8% of the total population). The dependent variable is $TotValue_i$. Table 4.29 presents the results for the 21 independent variables plus the intercept term, for which 14 parameter estimates are statistically significant. *Mp35003a_B* is not significant. *DistInterstate* indicates a decrease in *TotValue* of \$0.57, *DistFreeways* of \$0.42, and *DistMajorArteries* of \$0.82 per foot away from the nearest transportation facility. *POE_DrivingTime* indicates that *TotValue* increases \$1,681 for every additional minute required to drive to the nearest POE. *ShopC_DrivingTime* is not significant. The model explains 14.6% of the variation. The Jarque-Bera statistic indicates that residuals are not normally distributed. The Koenker BP statistic is significant indicating nonstationarity or heteroskedasticity. The Joint Wald Statistic indicates that the overall model is significant.

Table 4.29. Qualifying Open Space—Total Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	-48158.24	25094.24	-1.92	0.05	14346.08	-3.36	0.00*	--------
ImpAge	-387.06	224.79	-1.72	0.09	131.70	-2.94	0.00*	4.58
Air	7654.71	10731.15	0.71	0.48	7133.82	1.07	0.28	4.06
$Baths^2$	12183.59	1346.23	9.05	0.00*	1601.45	7.61	0.00*	2.95
$Bedrooms^2$	158.72	827.83	0.19	0.85	768.54	0.21	0.84	1.71
Garage	23644.78	43968.48	0.54	0.59	23625.97	1.00	0.32	1.02
Depreciable	857.68	246.21	3.48	0.00*	121.16	7.08	0.00*	2.93
LandAcres	220.18	12.28	17.93	0.00*	109.82	2.00	0.04*	1.02
ImpSize	11.85	1.48	8.03	0.00*	1.88	6.31	0.00*	3.17
Stories	-8511.30	9209.21	-0.92	0.36	4998.30	-1.70	0.09	4.46
Vacant	-42534.26	6776.46	-6.28	0.00*	5733.10	-7.42	0.00*	2.87
PopDens_CY	0.26	1.65	0.16	0.87	1.70	0.16	0.88	1.83
Renter_CY	-174.24	20.91	-8.33	0.00*	56.27	-3.10	0.00*	3.21
Vacant_CY	674.26	66.26	10.18	0.00*	289.07	2.33	0.02*	3.01
Unemp_CY	-96.27	23.16	-4.16	0.00*	37.51	-2.57	0.01*	1.91
PCI_CY	0.72	0.25	2.89	0.00*	0.52	1.37	0.17	1.48
Mp35003a_B	164.16	37.12	4.42	0.00*	103.51	1.59	0.11	3.15
DistInterstate	-0.57	0.11	-5.42	0.00*	0.20	-2.92	0.00*	6.61
DistFreeways	-0.42	0.07	-5.88	0.00*	0.13	-3.10	0.00*	4.27
DistMajorArteries	-0.82	0.17	-4.75	0.00*	0.17	-4.92	0.00*	4.78
POE_DrivingTime	1681.21	266.33	6.31	0.00*	305.74	5.50	0.00*	8.02
ShopC_DrivingTime	-363.91	222.15	-1.64	0.10	243.68	-1.49	0.14	5.99

Observations: 9739	AICc: 253137
Multiple R-Squared: 0.148	Adjusted R-Squared: 0.146

Joint F-Statistic:	80	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	1917	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	272	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	1151215923	Prob(>chi-squared), (2) degrees of freedom:	0.00*

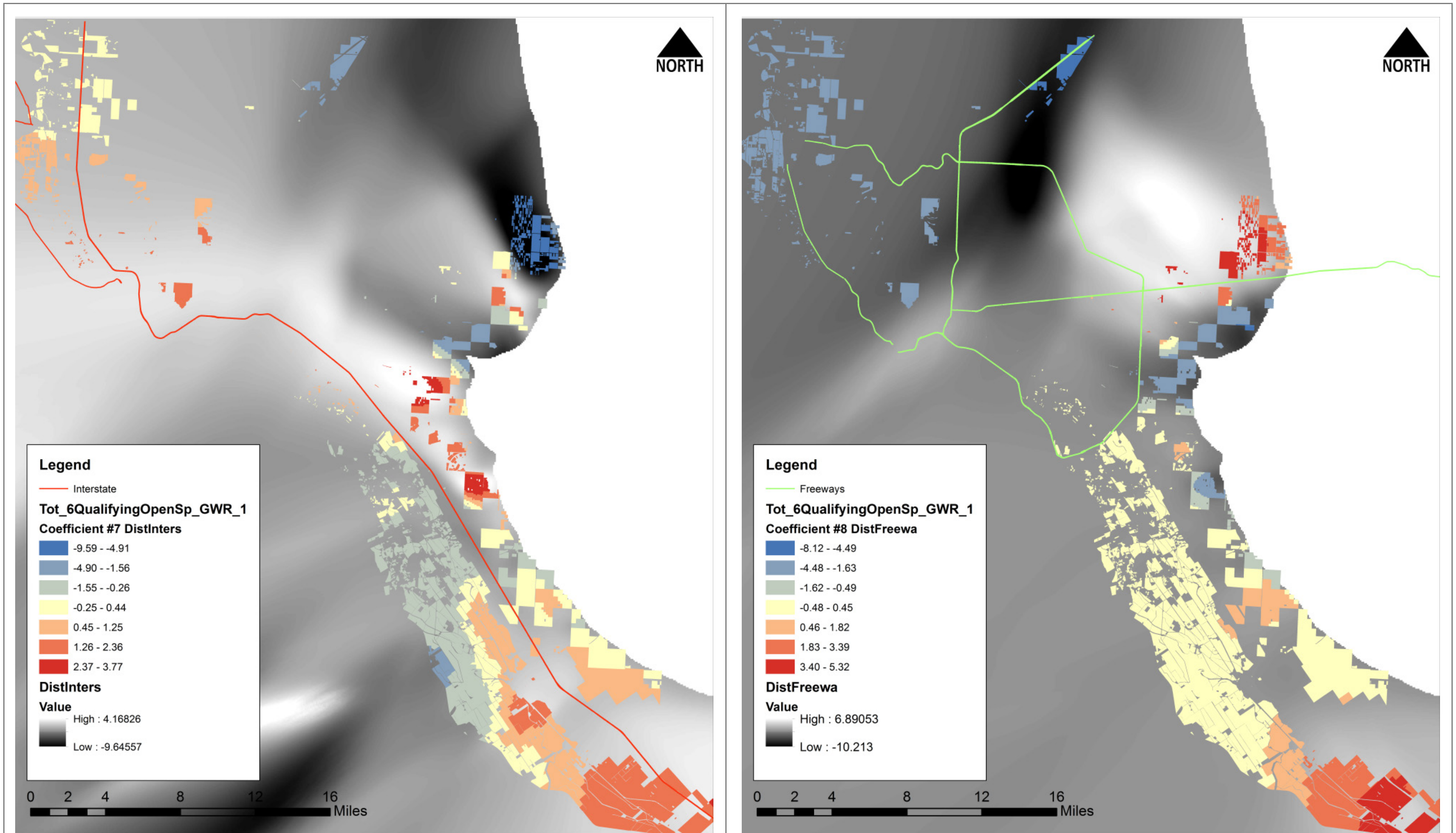
*Statistically significant probabilities have an asterisk next to them.

The GWR total value model yields 5,176 regression points with invertible matrices, which represent 53.1% from the qualifying open space sample (Table 4.30). By comparing the mean of the local coefficients, all the signs are consistent with their OLS counterparts, but the GWR coefficients have smaller magnitudes. Figure 4.27 shows the location of the GWR total value model coefficients for qualifying open space. *DistInterstate* indicates that *TotValue* decreases $0.17 per foot according to the mean. Local coefficients for *DistInterstate* range from a negative $9.59 per foot to a positive $3.77 per foot depending on their location, as shown in Figure 4.27(a). *DistFreeways* indicates that *TotValue* decreases $0.13 per foot according to the mean. Local coefficients for *DistFreeways* range from a negative $8.1 to a positive $5.3 per foot, as shown in Figure 4.27(b). *DistMajorArteries* indicates that *TotValue* decreases $0.15 per foot according to the mean. *DistMajorArteries* ranges from a negative $14.1 to a positive $18.6 per foot, as shown in Figure 4.27(c).

Table 4.30. Qualifying Open Space—Total Value Model GWR Summary Statistics

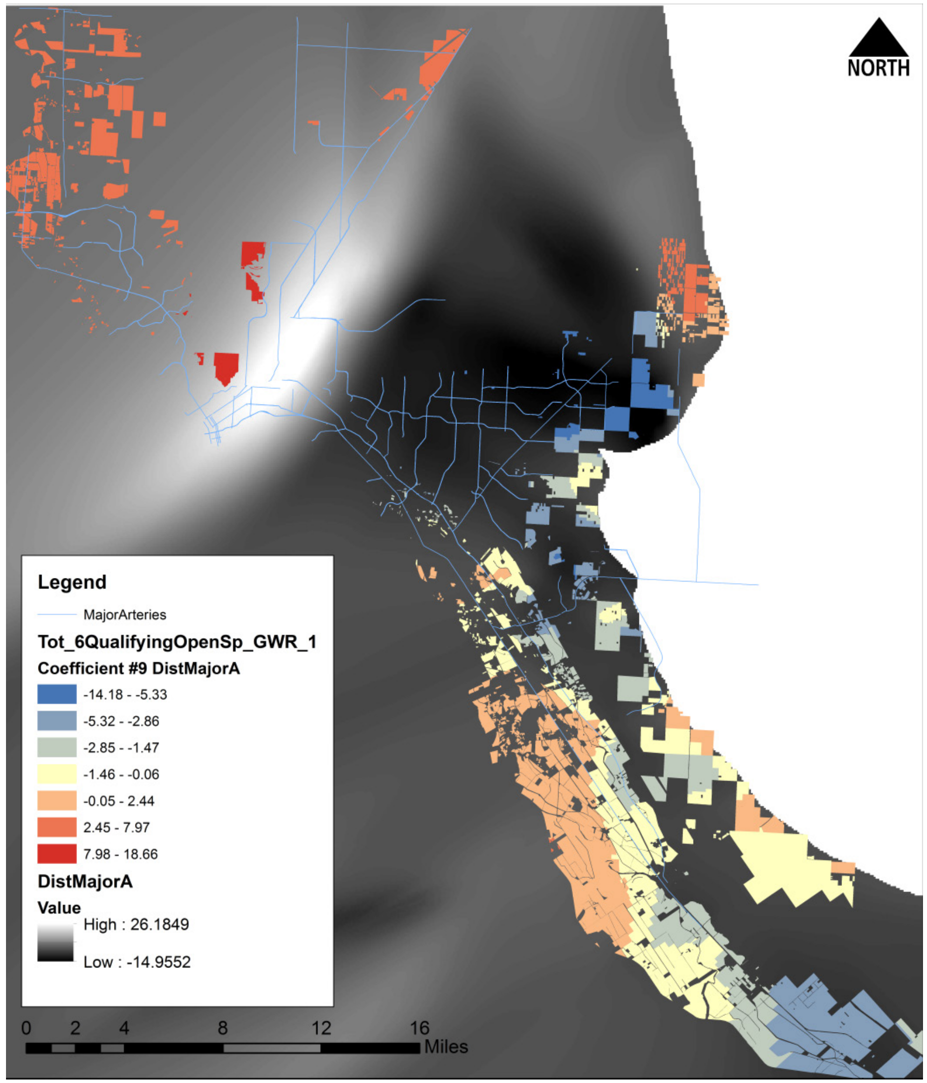
	Local coefficient estimates			Std. Error		
Variable	Mean	Min	Max	Mean	Min	Max
Intercept	-51619	-361444	235840	26636	12183	116470
ImpAge	137	-2041	6978	271	101	1568
$Baths^2$	13635	-206324	223471	3974	444	59511
Depreciable	697	-737	3092	247	115	1072
LandAcres	1810	10.2	9125	39.1	9.94	97.8
ImpSize	8.32	-103	88.9	3.15	0.623	29.6
Unemp_CY	10.1	-473	1634	50.8	8.95	378
DistInterstate	-0.178	-9.59	3.77	0.283	0.067	0.741
DistFreeways	-0.133	-8.12	5.31	0.187	0.098	0.770
DistMajorArteries	-0.159	-14.1	18.6	0.498	0.164	1.11
Residual Squares:	51867288682	Sigma:	29780	R^2:	0.643	
Effective Number:	3.51	AICc:	1457	$AdjR^2$:	0.628	

The GWR global diagnostics show improvement over OLS for the $AIC_{c,}$ dropping from 253,137 to 1,457, and $AdjR^2$ improved from 0.146 in OLS to 0.628 in the GWR baseline model. Figure 4.28(a) indicates that spatial autocorrelation is a problem in the residuals from the OLS. Although GWR shows some improvement mitigating the spatial autocorrelation problems, some hot and cold spots remain an issue for a significant number of parcels, as shown in red and blue respectively in Figure 28(b).



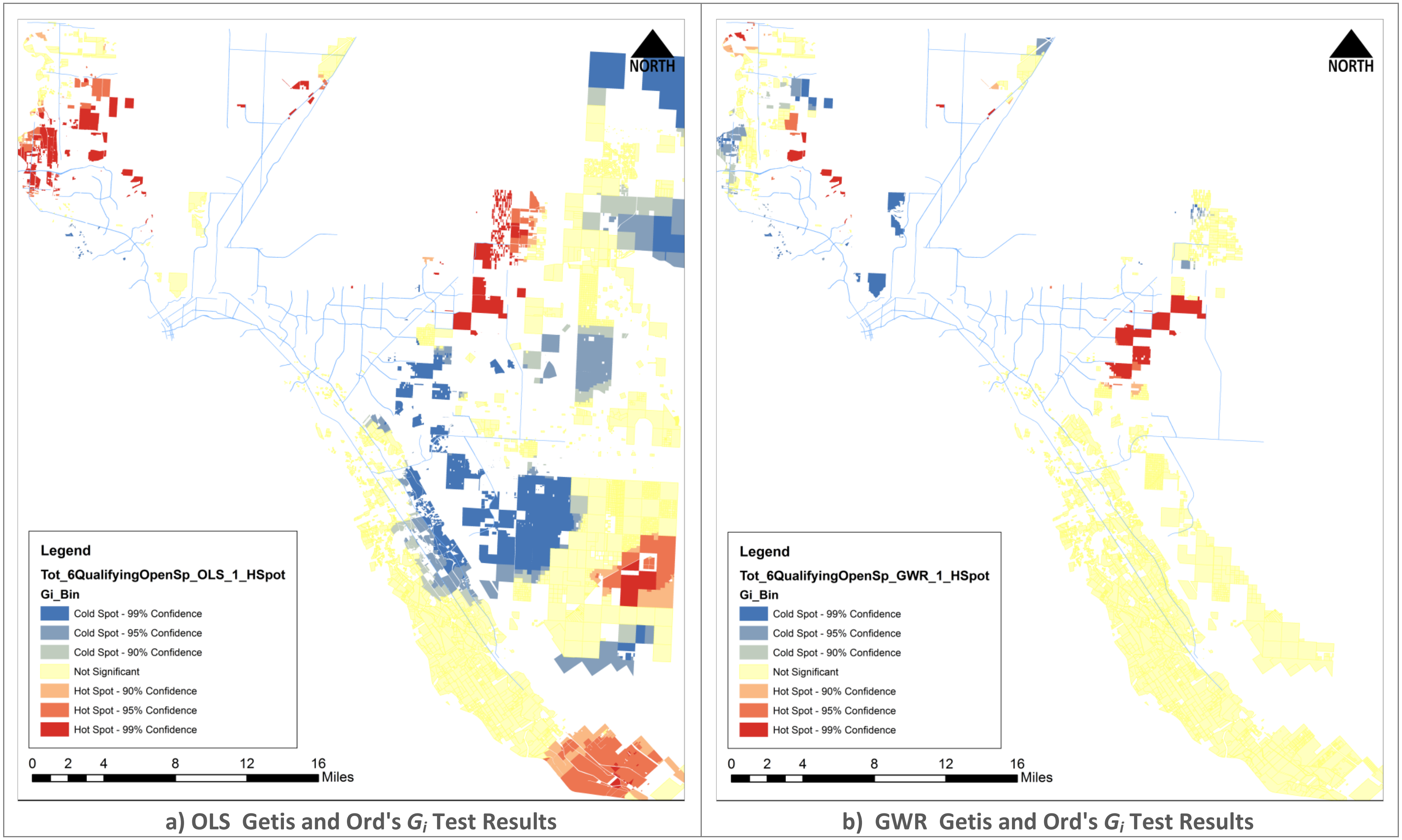
(a) *DistInterstate* (b) *DistFreeways*

Figure 4.27. Qualifying Open Space Total Value GWR Model Coefficients.



(c) *DistMajorArteries*

Figure 4.27. Qualifying Open Space Total Value GWR Model Coefficients (continuation).



a) OLS Getis and Ord's G_i Test Results

b) GWR Getis and Ord's G_i Test Results

Figure 4.28. Qualifying Open Space Total Value Model Spatial Autocorrelation Test Results.

4.6.2. Qualifying Open Space Improvement Value Model

The improvement value sample for qualifying open space includes 9,739 observations (2.8% of the total population). The dependent variable is $ImpValue_i$. Table 4.31 presents the results for the 20 independent variables plus the intercept term, from which 14 are statistically significant according to robust 95% confidence intervals. *Mp35003a_B* is not significant. *ImpValue* decreases $0.03 per foot as *DistInterstate* increases. *DistFreeways* indicate a similar decrease in *ImpValue* of $0.04 per foot. *DistMajorArteries* is not significant. *ImpValue* increases $156 for every additional minute it takes to drive to the nearest POE as shown by *POE_DrivingTime*. *ShopC_DrivingTime* indicates that *ImpValue* decreases $201 for every additional minute it takes to drive to the nearest shopping center. The adjusted R^2 indicates that the improvement value model explains 78.5% of the variation in the dependent variable. The significant Jarque-Bera statistic indicates that the residuals are not normal. The Koenker BP statistic is significant, indicating nonstationarity or heteroskedasticity. The Joint Wald Statistic indicates that the overall model is significant.

Table4.31. Qualifying Open Space—Improvement Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	-42843.98	4211.11	-10.17	0.00*	9942.04	-4.31	0.00*	--------
ImpAge	-282.88	37.21	-7.60	0.00*	125.05	-2.26	0.02*	4.26
Air	33104.35	1711.89	19.34	0.00*	6598.45	5.02	0.00*	3.51
$Baths^2$	12375.84	230.88	53.60	0.00*	1558.73	7.94	0.00*	2.95
$Bedrooms^2$	975.98	141.10	6.92	0.00*	648.10	1.51	0.13	1.69
Garage	33216.65	7522.78	4.42	0.00*	16648.36	2.00	0.05*	1.02
Depreciable	511.97	41.02	12.48	0.00*	100.57	5.09	0.00*	2.77
LandAcres	4.57	2.10	2.17	0.03*	2.47	1.85	0.06	1.02
ImpSize	12.78	0.25	51.88	0.00*	1.89	6.77	0.00*	3.00
PopDens_CY	-0.93	0.28	-3.28	0.00*	0.36	-2.61	0.01*	1.83
Renter_CY	-9.96	3.58	-2.78	0.01*	3.12	-3.19	0.00*	3.20
Vacant_CY	-2.04	11.37	-0.18	0.86	6.78	-0.30	0.76	3.01
Unemp_CY	-5.70	3.97	-1.43	0.15	1.99	-2.86	0.00*	1.91
PCI_CY	-0.22	0.04	-5.12	0.00*	0.04	-4.93	0.00*	1.48
Mp35003a_B	-4.74	6.36	-0.75	0.46	4.88	-0.97	0.33	3.14
DistInterstate	-0.03	0.02	-1.77	0.08	0.01	-3.04	0.00*	6.59
DistFreeways	-0.04	0.01	-2.88	0.00*	0.01	-3.08	0.00*	4.26
DistMajorArteries	-0.02	0.03	-0.83	0.41	0.03	-0.92	0.36	4.76
POE_DrivingTime	156.59	45.67	3.43	0.00*	48.73	3.21	0.00*	8.02

ShopC_DrivingTime	-201.12	38.00	-5.29	0.00*	33.30	-6.04	0.00*	5.95

Observations:	9739	AICc:	218795
Multiple R-Squared:	0.785	Adjusted R-Squared:	0.785
Joint F-Statistic:	1872	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	2456	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	1535	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	13184323	Prob(>chi-squared), (2) degrees of freedom:	0.00*

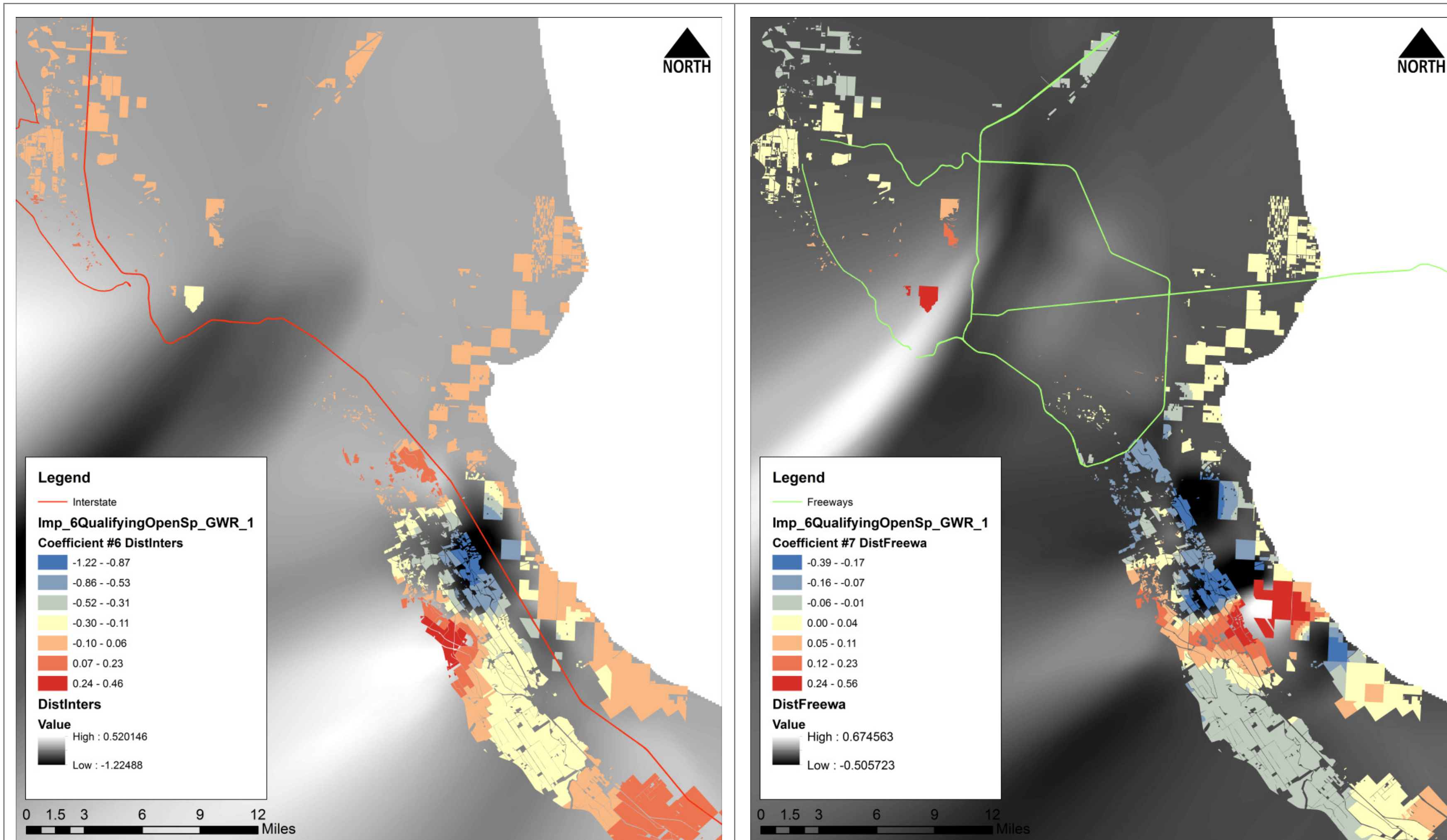
*Statistically significant probabilities have an asterisk next to them.

The GWR improvement value model estimation for qualifying open space yields 5,176 regression points with invertible matrices, 96.1% of the qualifying open space total sample (in Table 4.32). By comparing the mean values of the local coefficients, the signs of *DistInterstate* and *DistFreeways* are consistent with the OLS counterparts, but the GWR coefficients exhibit larger magnitudes. As *DistInterstate* increases, *ImpValue* decreases $0.12 per foot according to the mean. Local coefficients for *DistInterstate* range from a negative $1.22 to a positive $0.46 per foot depending on their location, as seen in Figure 29(a). Although the *POE_DrivingTime* parameter is statistically significant, it is excluded from GWR because presented local multicollinearity issues in this model. As *DistFreeways* increases, *ImpValue* decreases $0.01 per foot according to the mean. Local coefficients for *DistFreeways* range from a negative $0.39 to a positive $0.56 per foot in *ImpValue*, as seen in Figure 29(b). *ShopC_DrivingTime* indicates that *ImpValue* increases $104 per foot according to the mean. Local coefficients for *ShopC_DrivingTime* range from a negative $670 to a positive $2,399 per foot in *ImpValue*, as seen in Figure 29(c). The GWR *ShopC_DrivingTime* coefficient mean is positive, opposite the sign of the OLS parameter.

Table 4.32. Qualifying Open Space—Improvement Value Model GWR Summary Statistics

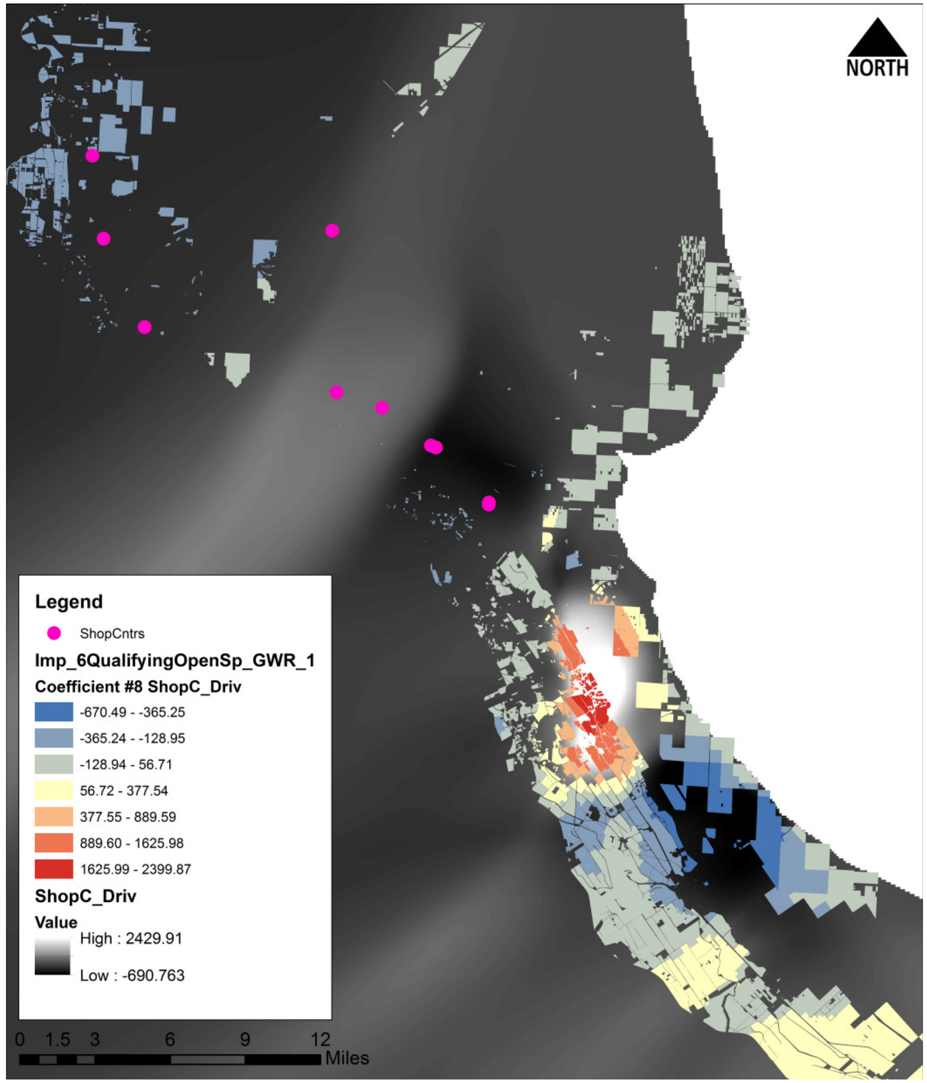
	Local coefficient estimates			Std. Error		
Variable	Mean	Min	Max	Mean	Min	Max
Intercept	-46370	-189414	65179	3568	1635	14673
ImpAge	138	-212	812	36.5	13.6	211
$Baths^2$	13804	-700	39699	534	60.0	8056
Depreciable	487	-627	1953	33.4	15.5	144
ImpSize	12.5	-2.45	24.7	0.423	0.084	4.00
PopDens_CY	-0.425	-8.58	86.6	0.427	0.094	11.3
DistInterstate	-0.123	-1.22	0.462	0.036	0.007	0.077
DistFreeways	-0.015	-0.391	0.562	0.027	0.011	0.065
ShopC_DrivingTime	104	-670	2399	69.8	18.9	218
Residual Squares:	62038917	Sigma:	4017	R^2:	0.701	
Effective Number:	0.156	AICc:	82.3	$AdjR^2$:	0.767	

The GWR global diagnostics show improvement over OLS for the $AIC_{c,}$ dropping from 218,795 to 82.3, respectively. $AdjR^2$ declined slightly from 0.785 in OLS to 0.767 in the GWR baseline model. Figure 4.30 illustrates that spatial autocorrelation is a problem for the OLS residuals. Most hot- and cold-spots disappear in the spatial autocorrelation test on the residuals from GWR; however, a few remain in the west side of the county.



(a) *DistInterstate* (b) *DistFreeways*

Figure 4.29. Qualifying Open Space Improvement Value GWR Model Coefficients.



(c) *ShopC_DrivingTime*

Figure 4.29. Qualifying Open Space Improvement Value GWR Model Coefficients (continuation).

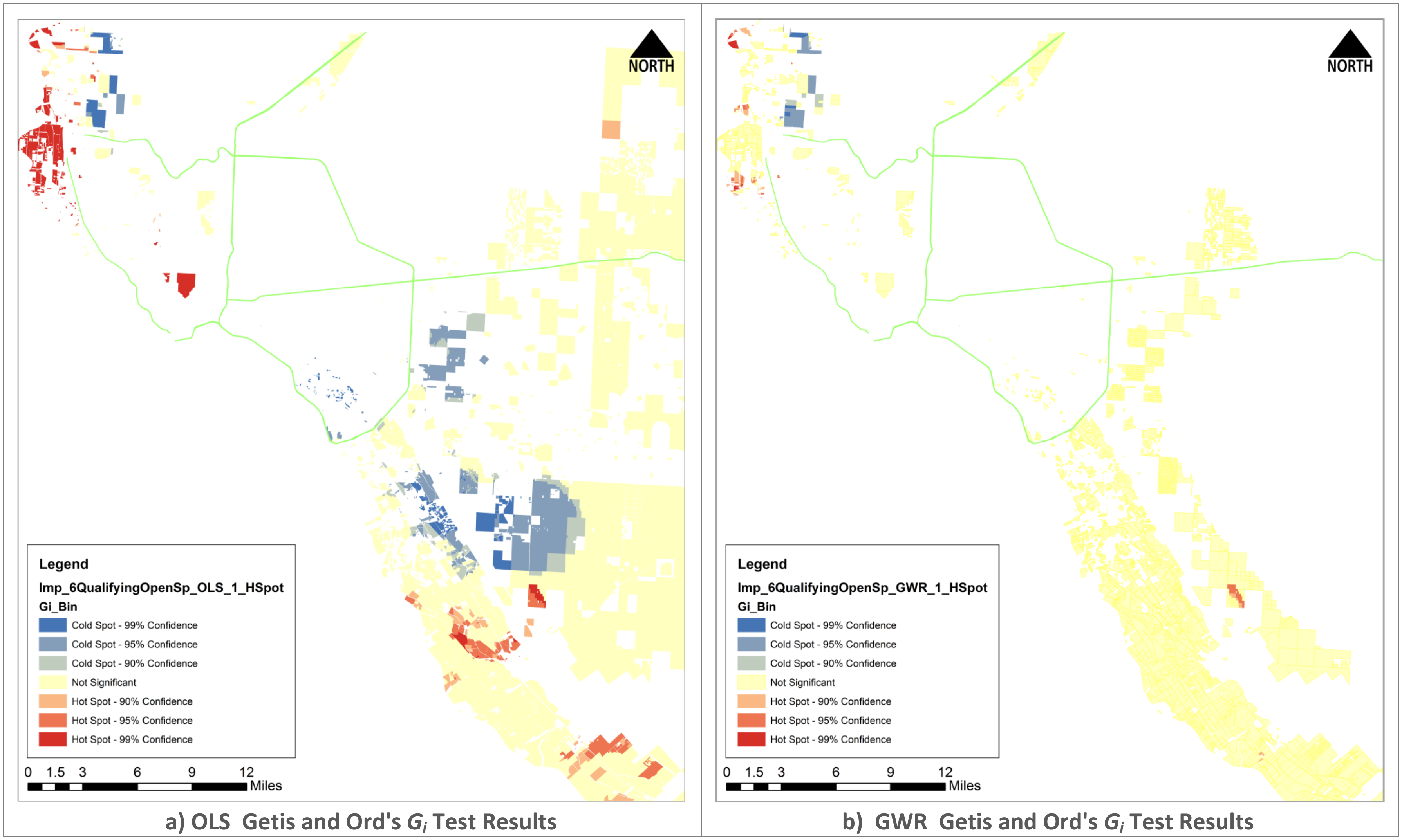


Figure 4.30. Qualifying Open Space Improvement Value Model Spatial Autocorrelation Test Results.

4.6.3. Qualifying Open Space Land Value Model

The land value sample for qualifying open space consists of 9,739 observations (2.8% of the total population). The dependent variable is *LandValue*$_i$. Table 4.33 presents the estimation results for the 6 independent variables plus the intercept term, from which 5 are statistically significant according to robust probabilities. *LandValue* increases $0.35 per foot as *DistInterstate* increases. *DistFreeways* indicates a similar increase in *LandValue* of $0.43 per foot. As *DistMajorArteries* increase, *LandValue* is expected to increase $0.75 per foot. *POE_DrivingTime* indicates that *LandValue* increases $1,739 for every additional minute it takes to drive to the nearest POE. *ShopC_DrivingTime* is significant only at the robust 90% confidence interval, and it indicates that *LandValue* increases $573 for every minute it takes to drive to the nearest shopping center. The *LandValue* model explains only 3.9% of the variation in the dependent variable. The residuals are not normal. The Koenker BP statistic is significant indicating nonstationarity or heteroskedasticity issues. The Joint Wald Statistic indicates that the overall model is significant.

Table 4.33. Qualifying Open Space—Land Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	7027.96	4477.67	1.57	0.12	3448.56	2.04	0.04*	--------
LandAcres	181.84	12.13	14.99	0.00*	100.04	1.82	0.07	1.01
DistInterstate	0.35	0.10	3.69	0.00*	0.15	2.30	0.02*	5.48
DistFreeways	0.43	0.07	6.38	0.00*	0.10	4.13	0.00*	3.84
DistMajorArteries	0.75	0.16	4.54	0.00*	0.24	3.15	0.00*	4.38
POE_DrivingTime	1739.41	229.25	7.59	0.00*	359.10	4.84	0.00*	6.04
ShopC_DrivingTime	573.00	206.33	2.78	0.01*	327.91	1.75	0.08	5.25

Observations:	9739	AICc:	252969
Multiple R-Squared:	0.040	Adjusted R-Squared:	0.039
Joint F-Statistic:	68	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	170	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	162	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	1415698974	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

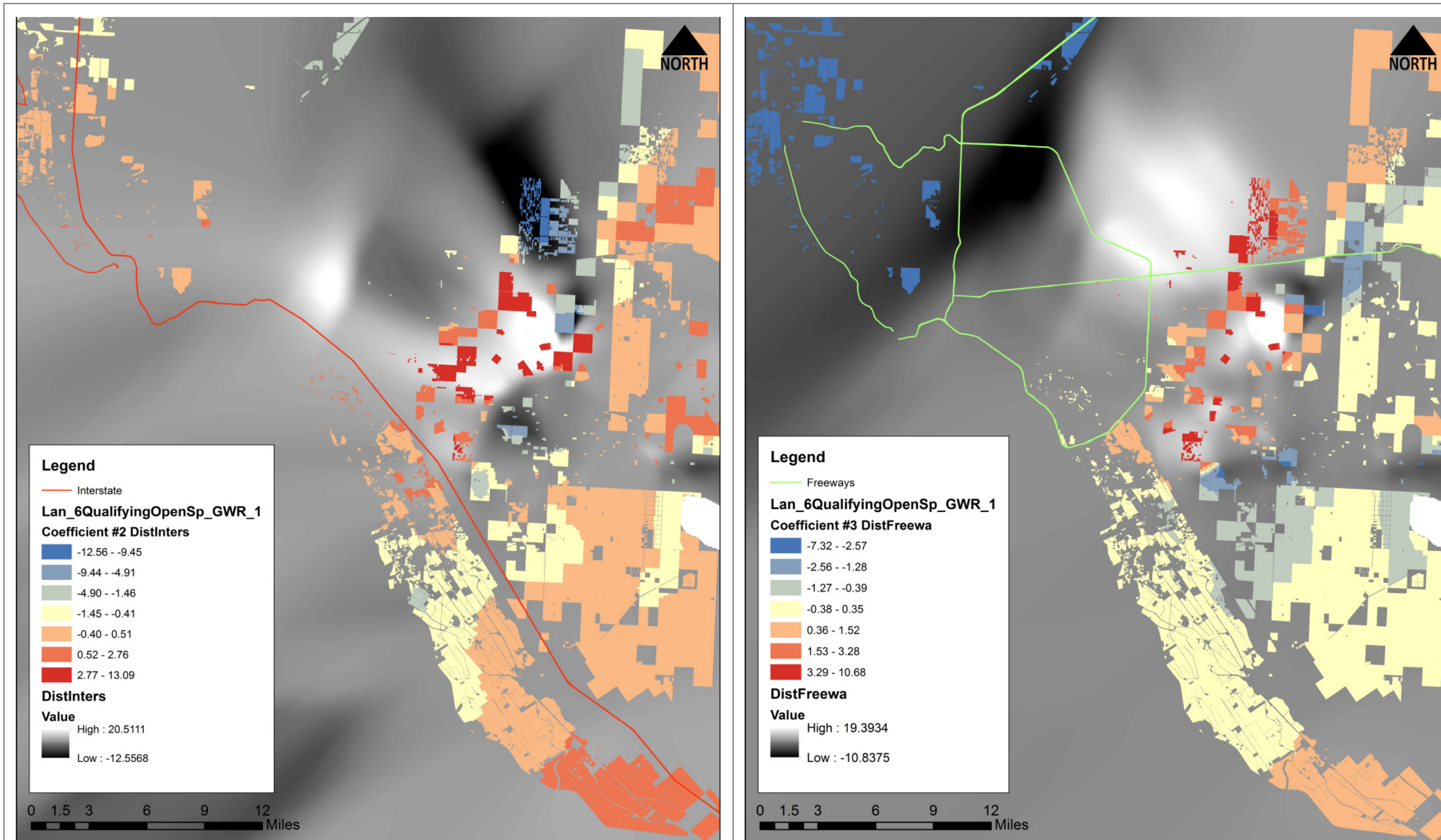
The GWR land value model estimation for qualifying open space yields 9,362 regression points with invertible matrices (Table 4.34). From the mean values of all local coefficients, *POE_DrivingTime* is the only one consistent its OLS counterpart. As *DistInterstate* increases, *LandValue* decreases $0.40 per foot according to the mean. *DistInterstate* ranges from a negative $12.50 to an increase of $13.00 per foot depending on their location, as illustrated in Figure 31(a).

DistFreeways indicates that *LandValue* decreases $0.18 per foot according to the mean. Coefficients from *DistFreeways* range from a negative $7.32 to a positive $10.60 per foot in *LandValue*, as shown in Figure 31(b). As *DistMajorArteries* increases, *LandValue* decreases $0.40 per foot according to the mean. *DistMajorArteries* ranges from a negative $21.90 to a positive $14.50 per foot in *LandValue*, as illustrated in Figure 31(c). *POE_DrivingTime* indicates that for every additional minute it takes to drive to the nearest POE, *LandValue* increases $1,796 at the mean. *POE_DrivingTime* ranges from a negative $11,187 per minute to an increase of $38,197 per minute driving to the nearest POE, as illustrated in Figure 31(d). *ShopC_DrivingTime* indicates that for every minute it takes to drive to the nearest shopping center, *LandValue* decreases $1,776 according to the mean. Local coefficients for *ShopC_DrivingTime* range from a negative $32,073 per minute to an increase of $4,401 per minute, as illustrated in Figure 31(e).

Table 4.34. Qualifying Open Space—Land Value Model GWR Summary Statistics

	Local coefficient estimates			Std. Error		
Variable	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
Intercept	22658	-626129	613390	149090	16203	1177025
LandAcres	863	-83.3	9224	129	19.5	383
DistInterstate	-0.405	-12.5	13.0	2.52	0.247	13.4
DistFreeways	-0.184	-7.32	10.6	1.75	0.510	10.6
DistMajorArteries	-0.405	-21.9	14.5	3.43	0.517	16.3
POE_DrivingTime	1796	-11187	38197	4364	640	14213
ShopC_DrivingTime	-1776	-32073	4401	3453	736	9651
Residual Squares:	17747001265961	Sigma:	118606	R^2:	0.528	
Effective Number:	17.4	AICc:	33529	$AdjR^2$:	0.521	

The GWR global diagnostics show improvement over OLS with the AIC_c, declining from 252,969 to 33,529. $AdjR^2$ declined slightly from 0.039 in OLS to 0.521 in the GWR baseline model. Figure 4.32(a) illustrates that spatial autocorrelation is a problem in the standard residuals from OLS. Most hot- and cold-spots disappear in the spatial autocorrelation test on the residuals from GWR; however, a significant number remain in the west and a few on the east of the county, as seen in Figure 4.32(b). These hot- and cold-spots indicate that the GWR model is under- and over-predicting, respectively, for those particular locations. The underlying cause might be that, in such particular locations, there is insufficient variation among the explanatory variables for qualifying open space parcels causing some local multicollinearity issues, which are not completely addressed in the GWR estimation.



(a) *DistInterstate* (b) *DistFreeways*

Figure 4.31. Qualifying Open Space Land Value GWR Model Coefficients.

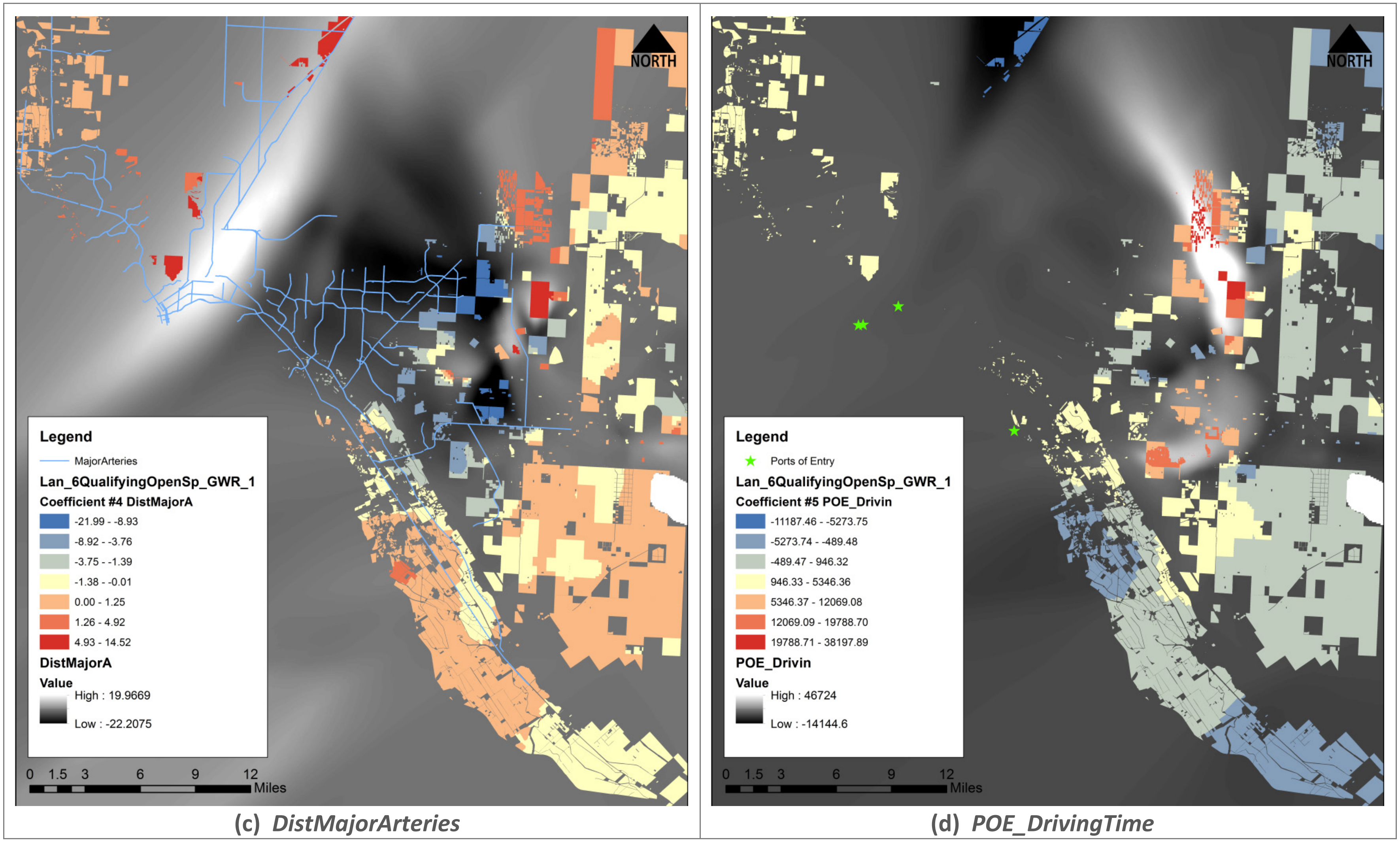
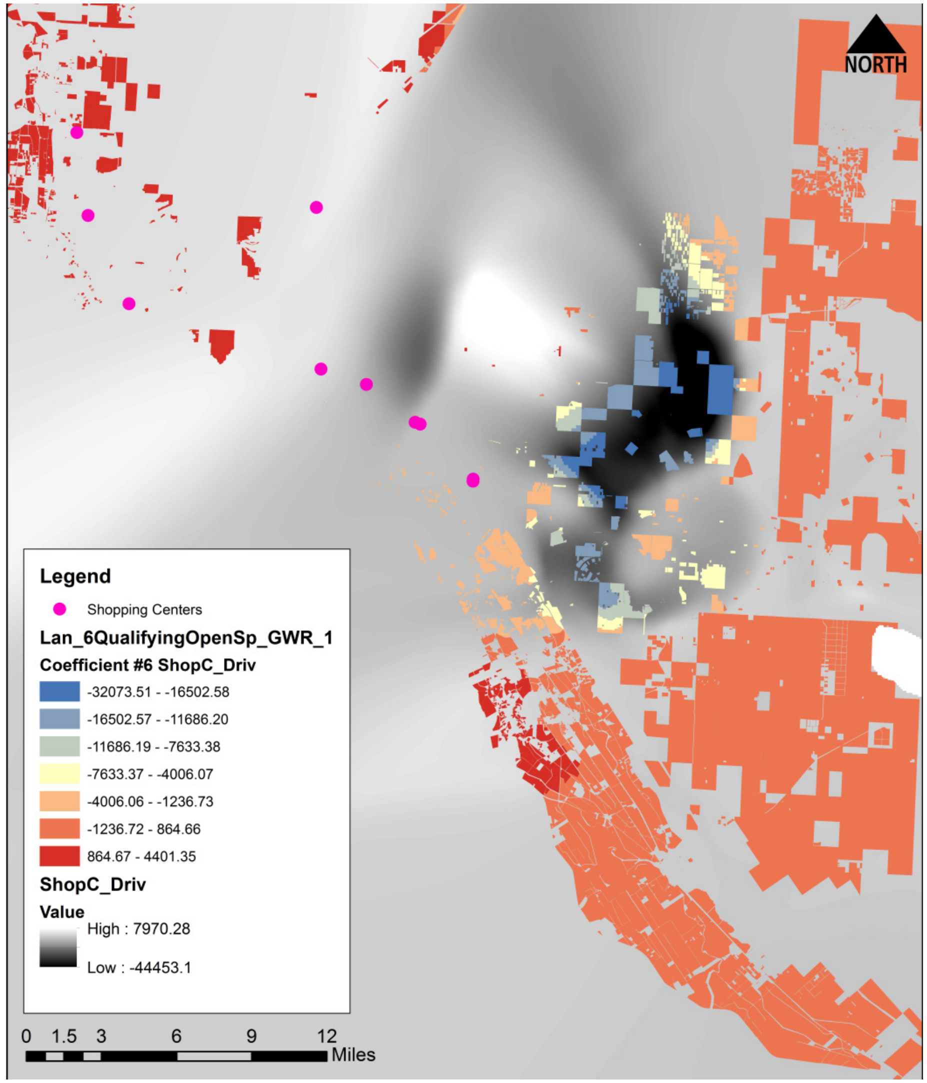


Figure 4.31. Qualifying Open Space Land Value GWR Model Coefficients (continuation).



(e) *ShopC_DrivingTime*

Figure 4.31. Qualifying Open Space Land Value GWR Model Coefficients (continuation).

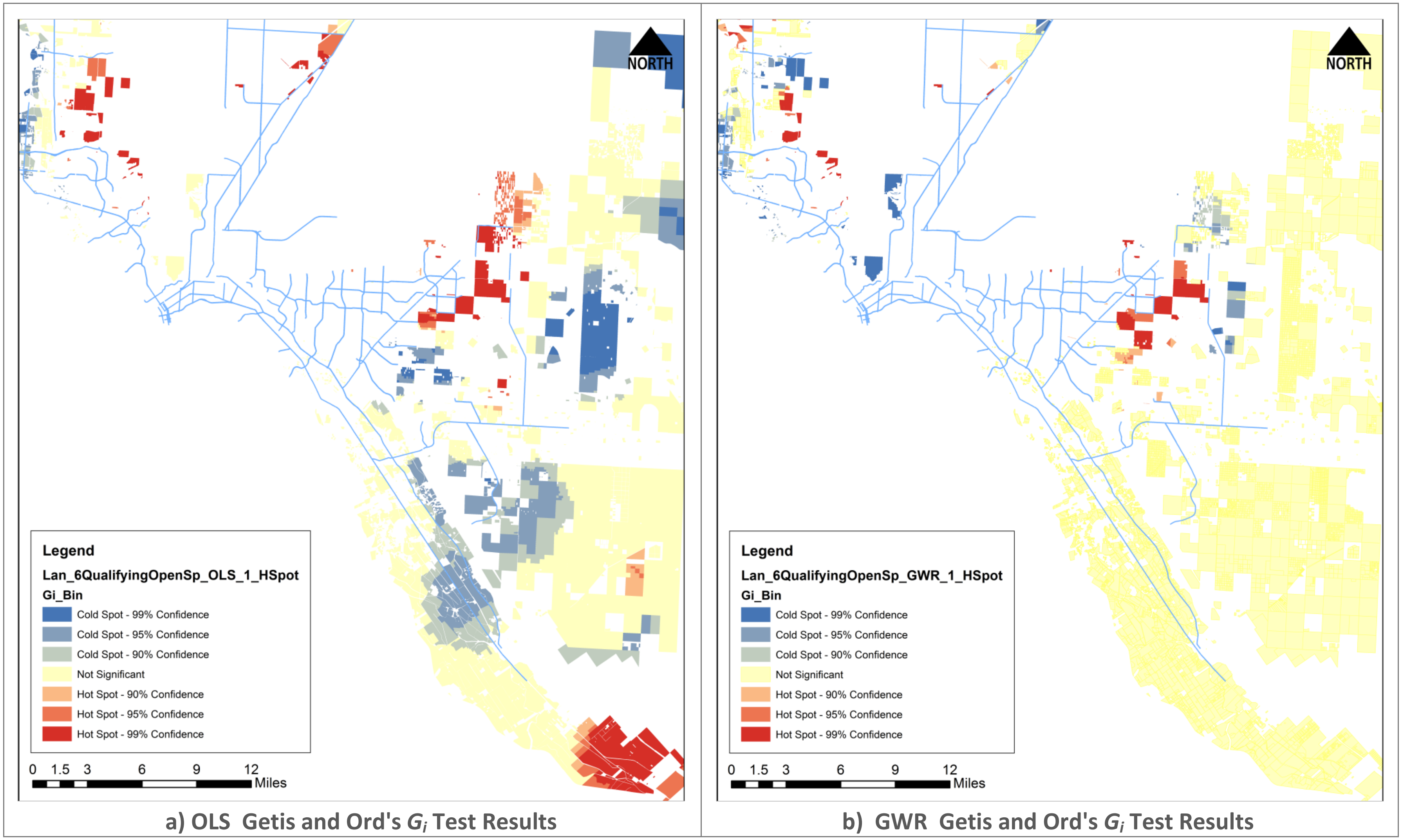


Figure 4.32. Qualifying Open Space Land Value Model Spatial Autocorrelation Test Results.

4.7. TRZ NOT ELIGIBLE

4.7.1. TRZ Not Eligible Total Value Model

The total value sample for TRZ Not Eligible includes 10,810 observations (3.0% of the total population). The dependent variable is $TotValue_i$. TRZ Not Eligible includes non-taxable property (e.g. government parcels, churches, universities, schools, etc.). Hence, the county market value, as appraised by EPCAD, was used as the dependent variable to quantify the impacts from transportation infrastructure for this category. Table 4.35 summarizes estimation results for the 20 independent variables plus the intercept, of which 11 are statistically significant according to robust 95% confidence intervals. *Mp35003a_B*, *DistInterstate*, and *POE_DrivingTime* are not significant. *DistFreeways* indicates a decrease in *TotValue* of $7.66 per foot. *DistMajorArteries* indicates a similar decrease in *TotValue* of $5.16 for every foot a parcel is located away from the nearest major artery. *ShopC_DrivingTime* indicates an increase of $10,180 for every minute an exempt parcel is located closer to a shopping center. Adjusted R^2 indicates that the total value model explains 39.8% of the variation. The Jarque-Bera statistic indicates that the residuals are not normally distributed. The Koenker BP statistic is significant indicating nonstationarity or heteroskedasticity. The Joint Wald Statistic indicates that the overall model is significant.

Table4.35. TRZ Not Eligible—Total Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	-603174.69	169179.09	-3.57	0.00*	257535.80	-2.34	0.02*	---
ImpAge	1707.94	1494.03	1.14	0.25	1416.36	1.21	0.23	4.01
Air	-172260.88	67356.35	-2.56	0.01*	145608.91	-1.18	0.24	3.42
$Baths^2$	-12368.00	13054.67	-0.95	0.34	15878.46	-0.78	0.44	2.60
$Bedrooms^2$	-26634.73	7245.04	-3.68	0.00*	6839.27	-3.89	0.00*	1.95
Garage	243611.66	167245.54	1.46	0.15	171628.62	1.42	0.16	1.61
Depreciable	17393.75	1648.15	10.55	0.00*	2268.57	7.67	0.00*	2.91
LandAcres	5320.84	190.39	27.95	0.00*	877.21	6.07	0.00*	1.06
ImpSize	29.12	0.41	70.18	0.00*	6.33	4.60	0.00*	1.14
Stories	-252415.58	49487.55	-5.10	0.00*	88418.71	-2.85	0.00*	3.21
Vacant	-905943.91	71167.82	-12.73	0.00*	217067.08	-4.17	0.00*	5.12
PopDens_CY	-16.07	4.72	-3.41	0.00*	4.46	-3.60	0.00*	1.76
Vacant_CY	-135.84	525.09	-0.26	0.80	519.78	-0.26	0.79	1.52
Unemp_CY	-633.68	276.35	-2.29	0.020*	537.87	-1.18	0.24	1.56
PCI_CY	0.02	1.83	0.01	0.99	1.76	0.01	0.99	1.56

Mp35003a_B	12.12	331.58	0.04	0.97	696.54	0.02	0.99	2.23
DistInterstate	-1.73	1.15	-1.50	0.13	1.53	-1.13	0.26	10.10
DistFreeways	-7.66	0.99	-7.75	0.00*	1.72	-4.46	0.00*	2.22
DistMajorArteries	-5.16	2.31	-2.23	0.03*	2.13	-2.42	0.02*	8.23
POE_DrivingTime	-2478.29	2745.88	-0.90	0.37	3750.40	-0.66	0.51	12.74
ShopC_DrivingTime	10180.18	2243.90	4.54	0.00*	3086.33	3.30	0.00*	6.91

Observations:	10810	AICc:	334805
Multiple R-Squared:	0.399	Adjusted R-Squared:	0.398
Joint F-Statistic:	358	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	4872	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	1869	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	111911774	Prob(>chi-squared), (2) degrees of freedom:	0.00*

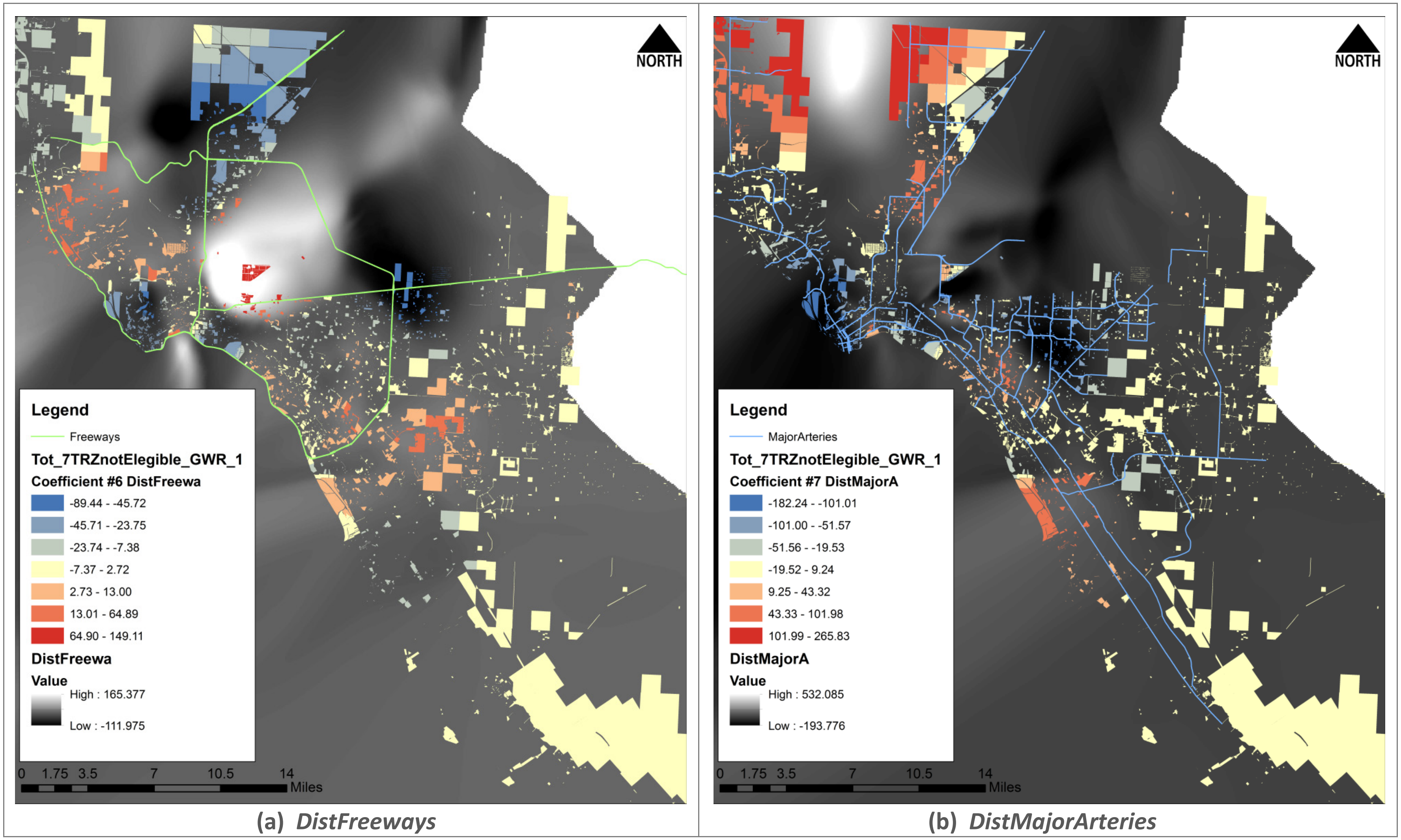
*Statistically significant probabilities have an asterisk next to them.

The GWR total value model estimation for TRZ not eligible yields all 10,810 regression points with invertible matrices (see Table 4.36). The signs of the mean coefficients are consistent with the OLS counterparts except for *ShopC_DrivingTime.* Figure 4.33 shows the GWR total value model coefficients for TRZ not eligible. As *DistFreeways* increases, *TotValue* decreases $6.38 per foot according to the mean. *DistFreeways* ranges from a negative $89.40 per foot to a positive $149 per foot in *TotValue* depending on their location, as shown in Figure 33(a). *DistMajorArteries* indicates a decrease of $15.40 per foot in *TotValue* according to the mean. Local coefficients for *DistMajorArteries* range from a negative $182 to a positive $265 per foot in *TotValue*, as shown in Figure 33(b). *ShopC_DrivingTime* indicates that for every additional minute it takes to drive to the nearest shopping center, *TotValue* decreases $4,081 according to the mean. *ShopC_DrivingTime* ranges from a negative $56,613 to a positive $98,524 per minute, as shown in Figure 33(c).

Table 4.36. TRZ Not Eligible—Total Value Model GWR Summary Statistics

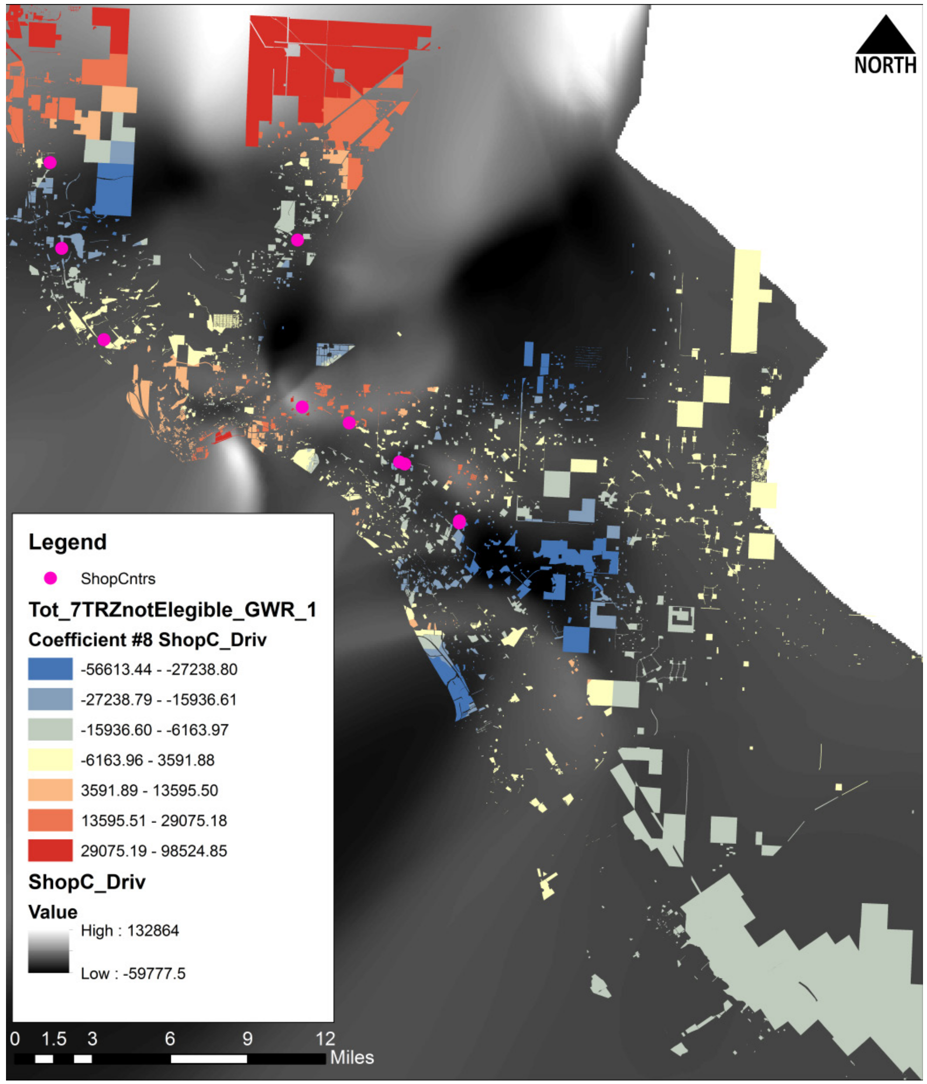
	Local coefficient estimates			Std. Error		
Variable	Mean	Min	Max	Mean	Min	Max
Intercept	-97921	-6866583	5934281	441516	165182	2421249
$Bedrooms^2$	-1087	-29004	51190	21927	8102	215858
Depreciable	3207	-56020	69025	4145	1413	24075
LandAcres	21978	438	256072	2892	259	14028
ImpSize	25.9	-19.4	78.9	3.72	0.498	238
PopDens_CY	-4.12	-165	1348	35.5	6.52	1002
DistFreeways	-6.38	-89.4	149	11.4	1.74	26.2
DistMajorArteries	-15.4	-182	265	33.9	4.74	94.5
ShopC_DrivingTime	-4081	-56613	98524	11694	3940	30938
Residual Squares:	4067136013551477	Sigma:	868247	R^2:	0.815	
Effective Number:	129	AICc:	166858	$AdjR^2$:	0.810	

The GWR global diagnostics show improvement over OLS with the AIC_c declining from 334,805 to 166,858 respectively. $AdjR^2$ declined slightly from 0.039 in OLS to 0.811 in the GWR baseline model. Figure 4.32(a) illustrates that spatial autocorrelation is a problem in the standard residuals from OLS. Most hot- and cold-spots disappear in the spatial autocorrelation test on the residuals from GWR; however, a few spots remain on the west side of the county, as shown in Figure 4.32(b).



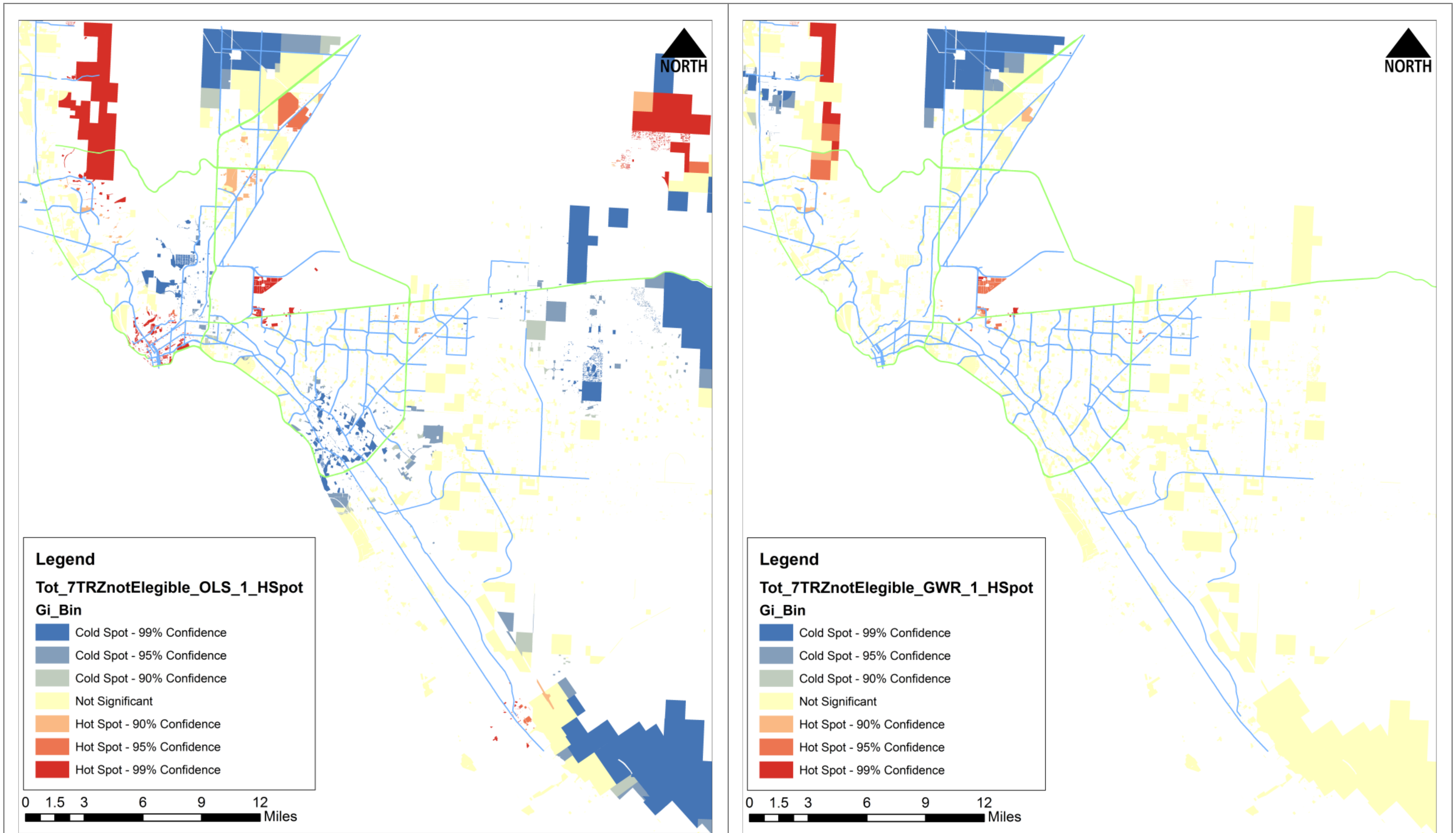
(a) *DistFreeways* (b) *DistMajorArteries*

Figure 4.33. TRZ Not Eligible Total Value GWR Model Coefficients.



(c) *ShopC_DrivingTime*

Figure 4.33. TRZ Not Eligible Total Value GWR Model Coefficients (continuation).



a) OLS Getis and Ord's G_i Test Results

b) GWR Getis and Ord's G_i Test Results

Figure 4.34. TRZ Not Eligible Total Value Model Spatial Autocorrelation Test Results.

4.7.2. TRZ Not Eligible Improvement Value Model

The improvement value sample for TRZ not eligible consists of 10,810 observations (3.0% of the total population). The dependent variable is *ImpValue*$_i$. The county market value, as appraised by EPCAD, was used as the dependent variable. Table 4.37 reports estimation results for the 21 independent variables plus the intercept term, of which 12 are statistically significant according to robust 95% confidence intervals. *DistInterstate*, *DistFreeways*, and *DistMajorArteries* are not significant. *Mp35003a_B* indicates that *ImpValue* decreases $780 for every person with 3 or more air-trips/year in the block where a TRZ not eligible improvement is located. *POE_DrivingTime* indicates that for every additional minute it takes to drive from a TRZ not eligible property to the nearest POE, *ImpValue* decreases by $10,138. *As ShopC_DrivingTime* increases, an increase of $6,677 is expected for every minute an exempt parcel is located closer to a shopping center. The improvement value model explains 43.5% of the variation. The residuals are not normal. The Koenker BP confirms nonstationarity and heteroskedasticity. The Joint Wald Statistic indicates that the overall model is significant.

Table 4.37. TRZ Not Eligible—Improvement Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	-588751.05	131103.41	-4.49	0.00*	242174.40	-2.43	0.02*	-----
ImpAge	2286.23	1158.20	1.97	0.05*	1265.70	1.81	0.07	4.01
Air	-130200.90	52183.20	-2.50	0.01*	133613.30	-0.97	0.33	3.43
Baths^2	-2832.23	10115.08	-0.28	0.78	13383.80	-0.21	0.83	2.60
Bedrooms^2	-22866.17	5612.23	-4.07	0.00*	6182.70	-3.70	0.00*	1.95
Garage	319859.99	129563.45	2.47	0.01*	157418.32	2.03	0.04*	1.61
Depreciable	16053.47	1276.81	12.57	0.00*	2079.83	7.72	0.00*	2.91
LandAcres	20.23	147.49	0.14	0.89	76.95	0.26	0.79	1.06
ImpSize	26.24	0.32	81.61	0.00*	6.10	4.30	0.00*	1.14
Stories	-311980.14	38337.02	-8.14	0.00*	84074.67	-3.71	0.00*	3.21
Vacant	-816414.73	55136.71	-14.81	0.00*	198758.15	-4.11	0.00*	5.13
PopDens_CY	-9.46	3.83	-2.47	0.01*	3.25	-2.92	0.00*	1.94
Renter_CY	-198.53	66.24	-3.00	0.00*	81.25	-2.44	0.01*	1.81
Vacant_CY	725.53	425.23	1.71	0.09	406.69	1.78	0.07	1.67
Unemp_CY	201.97	214.10	0.94	0.35	438.36	0.46	0.65	1.56
PCI_CY	0.07	1.42	0.05	0.96	1.40	0.05	0.96	1.57
Mp35003a_B	-780.24	261.66	-2.98	0.00*	241.01	-3.24	0.00*	2.31
DistInterstate	0.58	0.92	0.63	0.53	0.63	0.91	0.36	10.61
DistFreeways	-0.04	0.78	-0.05	0.96	0.51	-0.07	0.94	2.32
DistMajorArteries	-0.61	1.79	-0.34	0.73	1.08	-0.57	0.57	8.24

POE_DrivingTime	-10138.21	2130.37	-4.76	0.00*	2721.10	-3.73	0.00*	12.78
ShopC_DrivingTime	6677.08	1750.58	3.81	0.00*	2129.19	3.14	0.00*	7.01
Observations:	10810					AICc:	329285	
Multiple R-Squared:	0.436					Adjusted R-Squared:	0.435	
Joint F-Statistic:	397					Prob(>F), (21,198552) degrees of freedom:	0.00*	
Joint Wald Statistic:	4805					Prob(>chi-squared), (21) degrees of freedom:	0.00*	
Koenker (BP) Statistic:	1994					Prob(>chi-squared), (21) degrees of freedom:	0.00*	
Jarque-Bera Statistic:	443350058					Prob(>chi-squared), (2) degrees of freedom:	0.00*	

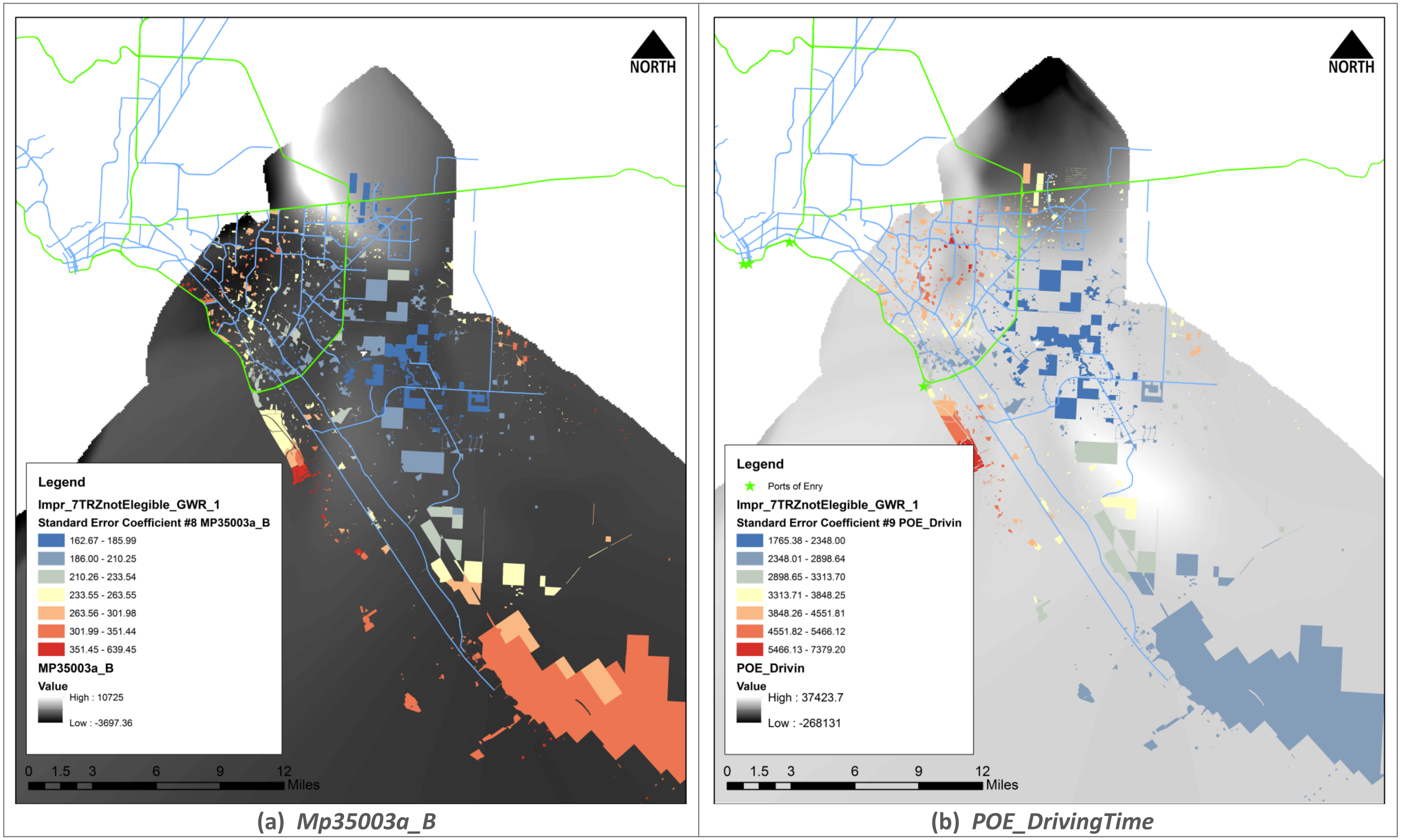
*Statistically significant probabilities have an asterisk next to them.

The GWR improvement value model estimation for TRZ not eligible properties yields 4,173 regression points with invertible matrices, which represent 38.6% from the TRZ not eligible sample (see Table 4.38). Figure 4.35 shows the GWR improvement value coefficients for TRZ not eligible parcels. As *Mp35003a_B* increases, *ImpValue* increases $204 for every person in the block with 3 air trips per year according to the mean. *Mp35003a_B* ranges from a negative $3,578 to a positive $7,583 per foot in *ImpValue* depending on their location, as shown in Figure 35(a). *POE_DrivingTime* indicates that *ImpValue* decreases $6,595 per minute according to the mean. Coefficients for *POE_DrivingTime* range from a negative $104,083 per minute to a positive $36,225 per minute, as shown in Figure 35(b). *ShopC_DrivingTime* indicates that for every additional minute it takes to drive to the nearest shopping center, *ImpValue* increases $2,899 according to the mean. *ShopC_DrivingTime* ranges from a negative $32,656 to an increase of $39,339 per minute depending on their location, as shown in Figure 35(c).

Table 4.38. TRZ Not Eligible—Improvement Value Model GWR Summary Statistics

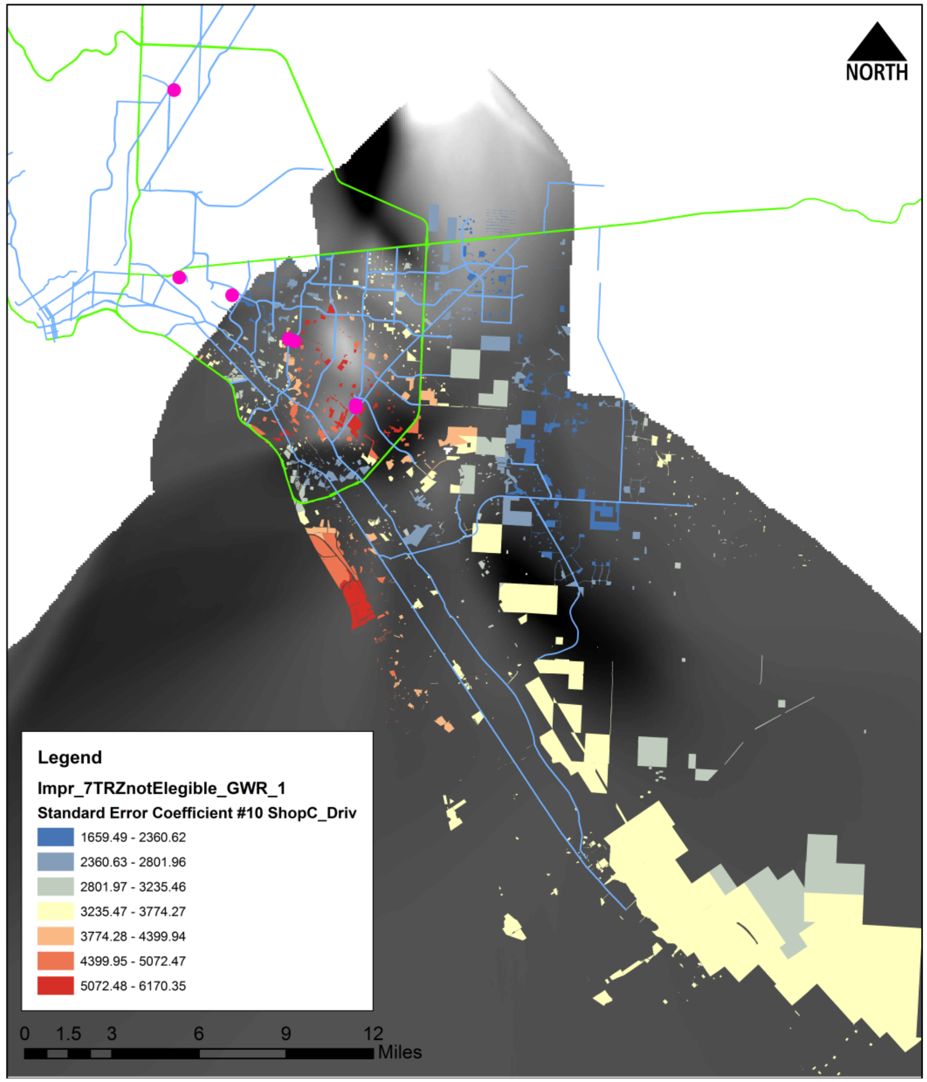
	Local coefficient estimates			Std. Error		
Variable	Mean	Min	Max	Mean	Min	Max
Intercept	-445567	-6823012	4298667	152129	81891	699082
$Bedrooms^2$	-41913	-352311	20991	5396	2930	17683
Garage	299928	-1241054	2017672	139966	37464	246830
Depreciable	15800	-27428	130564	1487	751	7281
ImpSize	13.3	-36.8	73.7	0.434	0.146	6.69
Stories	-396293	-3979131	225444	49013	18352	185239
Vacant	-1010921	-7432642	311898	58953	29543	210775
PopDens_CY	-1.94	-93.0	39.1	4.53	3.02	23.9
Mp35003a_B	204	-3578	7583	245	162	639
POE_DrivingTime	-6595	-104083	36225	3571	1765	7379
ShopC_DrivingTime	2899	-32656	39339	3383	1659	6170
Residual Squares: 12946633481253		Sigma: 224084		R^2: 0.550		
Effective Number: 10.1		AICc: 7372		$AdjR^2$: 0.534		

The GWR global diagnostics show improvement over OLS with the AIC_c dropping from 329,285 to 7,372 respectively. AdjR^2 increases from 0.435 in OLS to 0.534 in the GWR baseline model. Figure 4.36(a) illustrates that spatial autocorrelation is a problem in the standard residuals from OLS. Spatial autocorrelation practically disappears from the GWR, as shown in Figure 4.36(b).



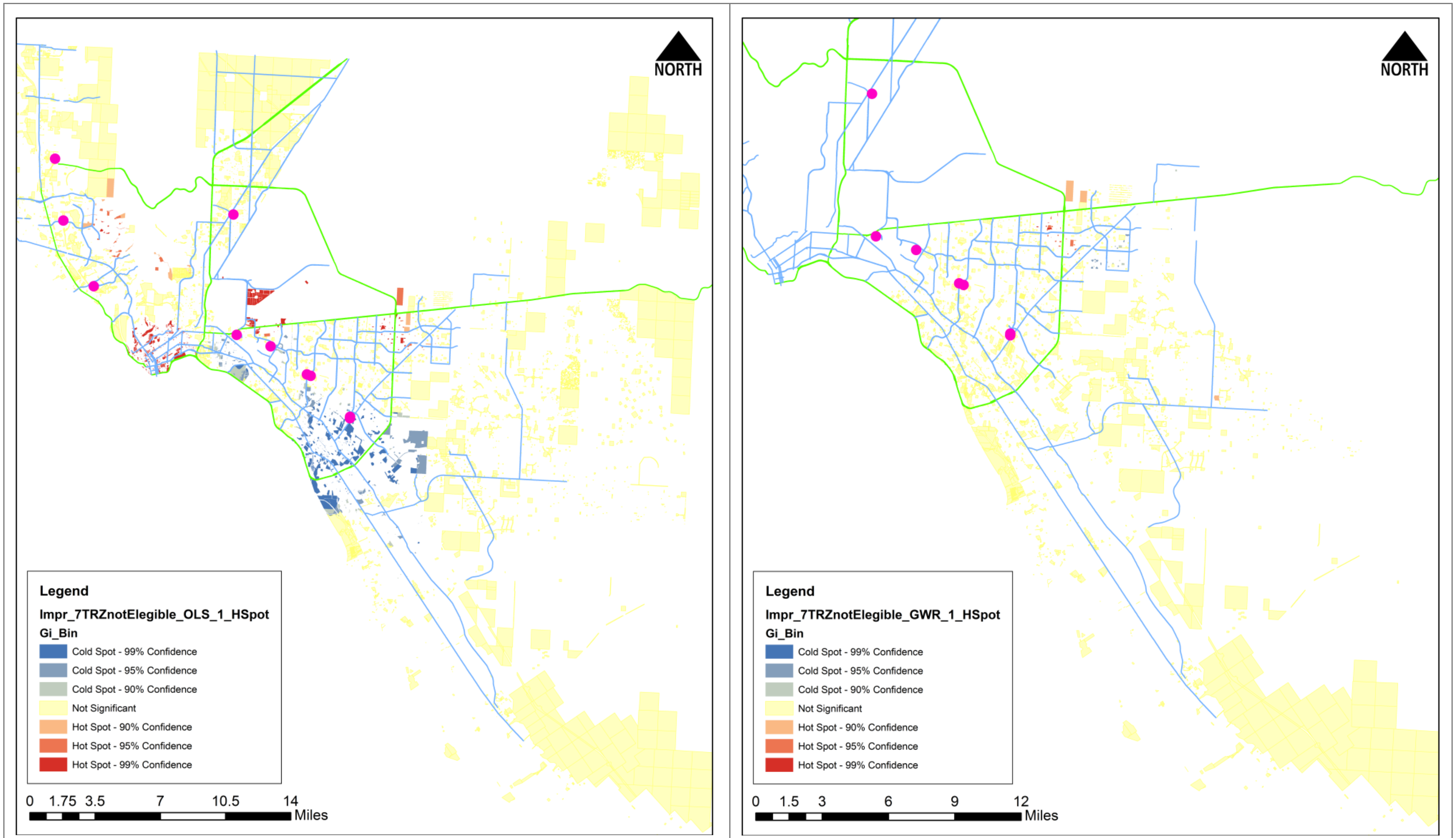
(a) *Mp35003a_B* (b) *POE_DrivingTime*

Figure 4.35. TRZ Not Eligible Improvement Value GWR Model Coefficients.



(c) *ShopC_DrivingTime*

Figure 4.35. TRZ Not Eligible Improvement Value GWR Model Coefficients (continuation).



a) OLS Getis and Ord's G_i Test Results

b) GWR Getis and Ord's G_i Test Results

Figure 4.36. TRZ Not Eligible Improvement Value Model Spatial Autocorrelation Test Results.

4.7.3. TRZ Not Eligible Land Value Model

The land value model for TRZ Not Eligible consists of 10,810 observations (3.0% of the total population) where the dependent variable is $LandValue_i$. The county market value, as appraised by EPCAD, was used as the dependent variable. Table 4.39 presents the results for the 6 independent variables plus the intercept term, from which 6 are statistically significant according to robust 95% confidence intervals. *ShopC_DrivingTime* is significant only at the robust 90% confidence interval. *DistInterstate* indicates an increase in *LandValue* of $4.11 per foot. *DistFreeways* indicates an increase in *LandValue* of $8.39 per foot. *DistMajorArteries* indicates a similar increase in *LandValue* of $3.25 for every additional foot a TRZ not eligible parcel is located away from the nearest major artery. *POE_DrivingTime* indicates that for every additional minute it takes to drive from a TRZ not eligible property to the nearest POE, *LandValue* increases $8,547. *ShopC_DrivingTime* indicates an increase of $3,798 for every minute an exempt parcel is located closer to a shopping center. Adjusted R^2 indicates that the land value model explains 19.7% of the variation. The Jarque-Bera statistic indicates that residuals are not normally distributed. The Koenker BP statistic is significant indicating nonstationarity or heteroskedasticity. The Joint Wald Statistic indicates that the overall model is significant.

Table 4.39. TRZ Not Eligible—Land Value Model OLS Estimation Results

Variable	Coef.	Std. Error	t-Stats.	Prob.	Robust SE	Robust t	Robust Prob.	VIF
Intercept	73203.35	17074.35	4.29	0.00*	26744.97	2.74	0.01*	--------
LandAcres	5310.34	108.49	48.95	0.00*	869.77	6.11	0.00*	1.05
DistInterstate	4.11	0.63	6.51	0.00*	1.31	3.15	0.00*	9.26
DistFreeways	8.39	0.55	15.16	0.00*	1.64	5.12	0.00*	2.13
DistMajorArteries	3.25	1.23	2.64	0.01*	1.48	2.20	0.03*	7.16
POE_DrivingTime	8547.16	1435.33	5.95	0.00*	2036.47	4.20	0.00*	10.65
ShopC_DrivingTime	3798.60	1250.61	3.04	0.00*	2127.11	1.79	0.07	6.56

Observations:	10810	AICc:	322703
Multiple R-Squared:	0.197	Adjusted R-Squared:	0.197
Joint F-Statistic:	442	Prob(>F), (21,198552) degrees of freedom:	0.00*
Joint Wald Statistic:	439	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Koenker (BP) Statistic:	1393	Prob(>chi-squared), (21) degrees of freedom:	0.00*
Jarque-Bera Statistic:	95268861	Prob(>chi-squared), (2) degrees of freedom:	0.00*

*Statistically significant probabilities have an asterisk next to them.

The GWR land value model yields 9,618 regression points with invertible matrices, 89% of the TRZ not eligible sample (see Table 4.40). As *DistInterstate* increases, *LandValue* decreases $5.80 per foot according to the mean. Local coefficients for *DistInterstate* range from a negative $91.00 per foot to a positive $59.80 per foot in *LandValue* depending on their location, as illustrated in Figure 37(a). *DistFreeways* indicates that *LandValue* decreases $4.65 per foot according to the mean. *DistFreeways* ranges from a negative $130 to an increase of $32.30 per foot in *LandValue*, as illustrated in Figure 37(b). As *DistMajorArteries* increases, *LandValue* decreases $21.10 per foot according to its GWR mean. Local coefficients for *DistMajorArteries* range from a negative $190 to an increase of $223 per foot in *LandValue*, as illustrated in Figure 37(c). *POE_DrivingTime* indicates that for every additional minute it takes to drive to the nearest POE, *LandValue* decreases $1,912 according to the mean. Local coefficients for *POE_DrivingTime* range from a negative $63,132 per minute to an increase of $181,034 per minute depending on their location, as illustrated in Figure 37(d).

Table 4.40. TRZ Not Eligible—Land Value Model GWR Summary Statistics

	Local coefficient estimates			Std. Error		
Variable	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
Intercept	180026	-963516	1760450	253471	42108	2923997
LandAcres	19067	223	103119	1555	163	7928
DistInterstate	-5.80	-91.0	59.8	9.76	1.71	44.7
DistFreeways	-4.65	-130	32.3	8.58	1.59	34.5
DistMajorArteries	-21.1	-190	223	20.9	2.86	54.5
POE_DrivingTime	-1912	-63132	181034	12218	4731	37728
Residual Squares:	995711260909799	Sigma: 495597		R^2: 0.766		
Effective Number:	76.1	AICc: 120083		AdjR^2: 0.762		

The GWR global diagnostics show improvement over OLS for the AIC_c dropping from 322,703 to 120,083 respectively. AdjR^2 increased significantly from 0.197 in OLS to 0.762 in the GWR baseline model. Figure 4.38(a) illustrates that spatial autocorrelation is a problem in the standard residuals from OLS. Spatial autocorrelation practically disappears in the GWR with very few clusters visible in the west side of the county, as shown in Figure 38(b).

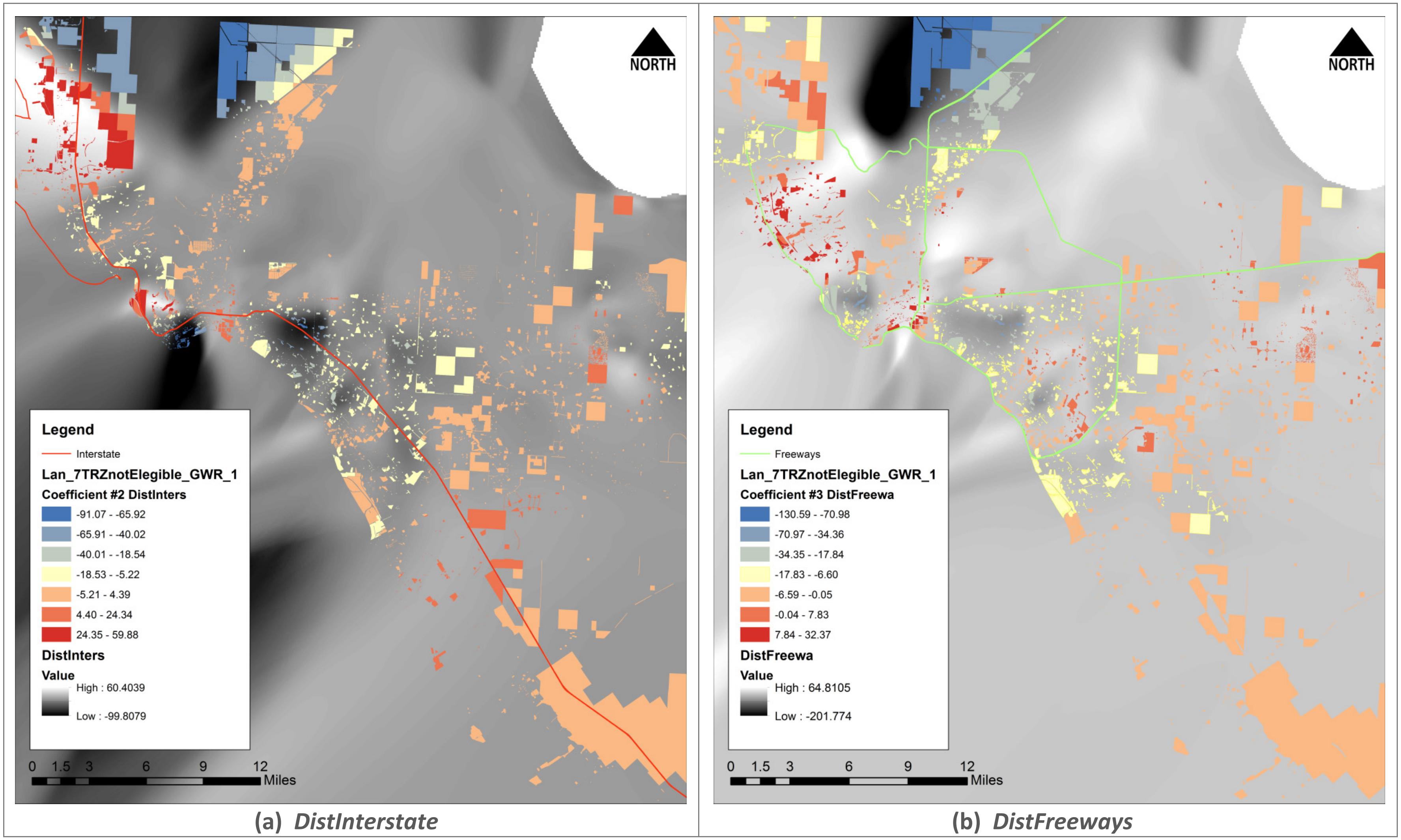
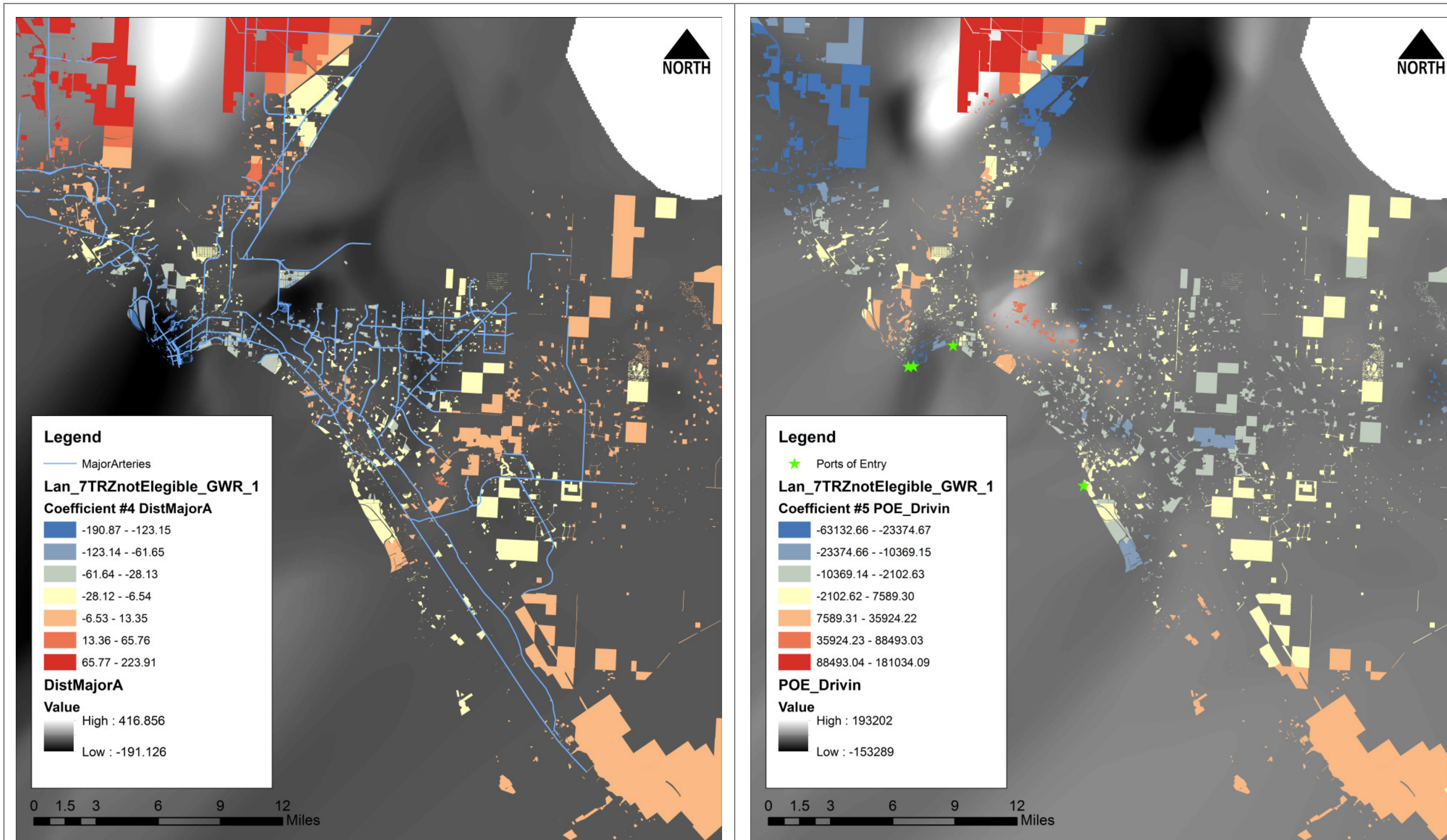
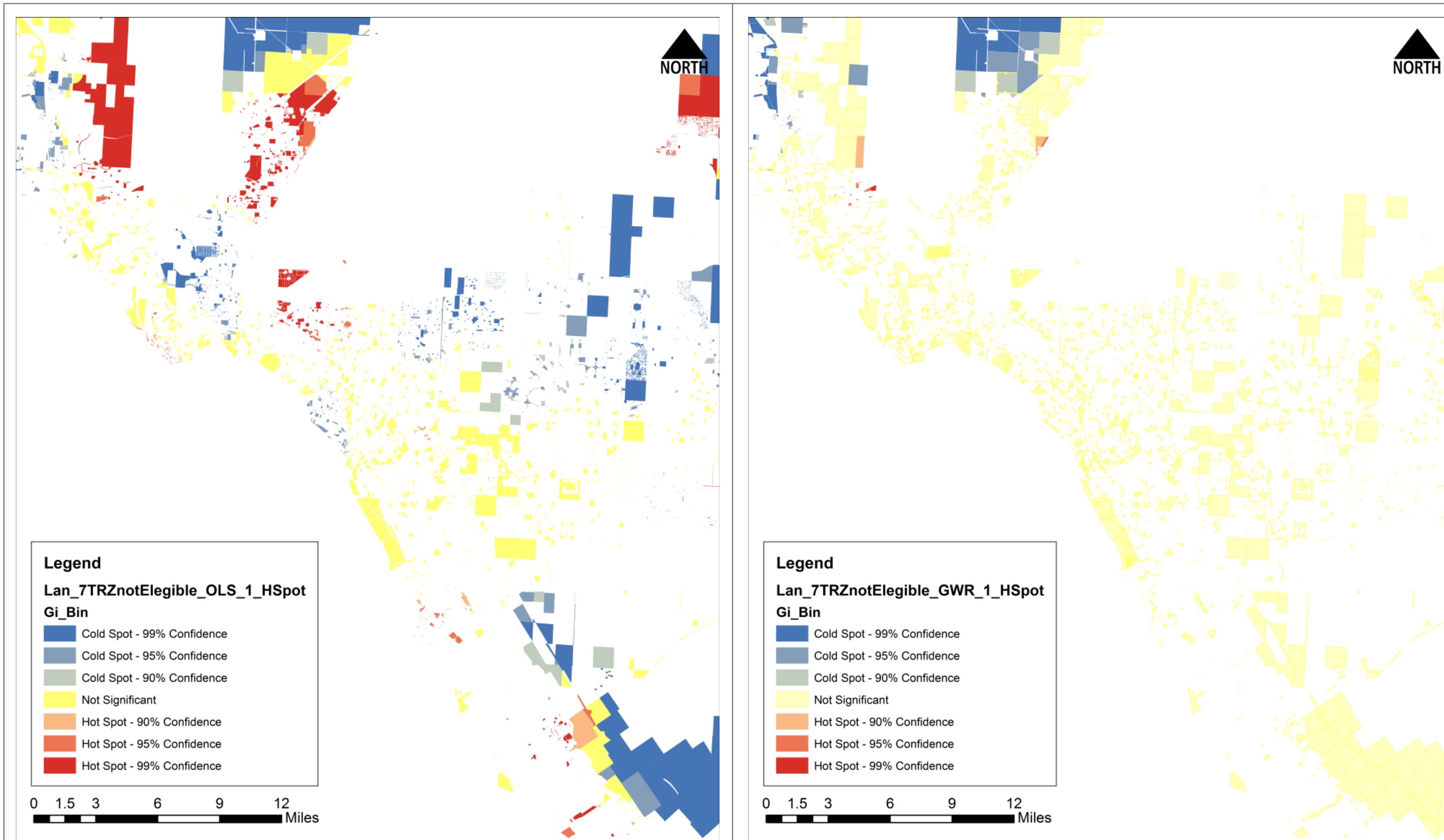


Figure 4.37. TRZ Not Eligible Land Value GWR Model Coefficients.



(c) *DistMajorArteries* (d) *POE_DrivingTime*

Figure 4.37. TRZ Not Eligible Land Value GWR Model Coefficients (continuation).



a) OLS Getis and Ord's G_i Test Results

b) GWR Getis and Ord's G_i Test Results

Figure 4.38. TRZ Not Eligible Land Value Model Spatial Autocorrelation Test Results.

Chapter 5: Conclusion

Traditional hedonic models that are global in nature can sometimes be misleading for examining the impacts of transportation infrastructure proximity and accessibility on real property values. Koenker BP tests confirm that problems with spatial nonstationarity and heteroskedasticity are present in 20 of the 21 models. Moreover, Jarque-Bera statistics indicate that residuals are not normally distributed for all 21 models. The GWR AIC_c are lower than the OLS AIC_c in all cases, and GWR $AdjR^2$ are higher for 16 of the 21 models. For all property types, the relationship between real property values and transportation infrastructure proximity and accessibility is highly localized and varies significantly over space. The presence of spatial nonstationarity and heterogeneity confirms that transportation infrastructure proximity and accessibility can generate premia on real property values, but positive premia are not always present and are negative in some areas. The location of a positive premium for some property types, primarily residential and commercial improvements, vary by socio-economic stratum, neighborhood, and locational characteristics of the parcel. The statistical significance of the *PopDens_CY*, *Unemp_CY*, *PCI_CY*, and *Depreciable* coefficient in almost all of the residential and commercial models provides evidence that these variables also play key roles in determining property values. Analyzing the manners in which these variables influence value premia merits separate attention.

Results for the total value and the improvement value models indicate that the impacts of transportation infrastructure on property values are greater for *POE_DrivingTime*, followed by *ShopC_DrivingTime*, *DistMajorArteries*, *DistFreeways,* and *DistInterstate*. The signs and magnitudes of the *DistFreeways* and *DistInterstate* parameters are very similar, regardless of the fact that the number of centerline miles of freeways is 67% greater than that for interstate highways. None of the parameter estimates for transportation infrastructure accessibility on real property values are statistically significant for the *TotValue* and *ImpValue* of industrial properties; only *ShopC_DrivingTime* and *DistMajorArteries* are for *LandValue*.

By sorting the statistically significant coefficients from negative to positive values, additional conclusions can be extracted from this research:

- *POE_DrivingTime* exhibits negative mean GWR coefficients of greater magnitude for the *TotValue*, *ImpValue*, and *LandValue* of commercial properties. *POE_DrivingTime* exhibits positive mean GWR coefficients of greater magnitude for the *TotValue* and *ImpValue* of multi-family units and for the *LandValue* of qualifying open space parcels.
- *ShopC_DrivingTime* exhibits negative mean GWR coefficients of greater magnitude for the *TotValue* and *ImpValue* of commercial properties and for the *LandValue* of industrial parcels. *ShopC_DrivingTime* exhibits positive mean GWR coefficients of greater magnitude for the *TotValue* and *ImpValue* of TRZ not eligible properties and for the *LandValue* of other residential parcels.
- *DistMajorArteries* exhibits negative mean GWR coefficients of greater magnitude for the *TotValue* and *ImpValue* of multi-family units and for the *LandValue* of TRZ not eligible and commercial parcels. Mean GWR *DistMajorArteries* coefficients for *TotValue* are negative for all property types. *DistMajorArteries* exhibits positive mean GWR coefficients of greater magnitude for the *ImpValue* of single-family units and for the *LandValue* of industrial parcels.
- *DistFreeways* exhibits negative mean GWR coefficients of greater magnitude for the *TotValue* and *ImpValue* of multi-family and TRZ not eligible properties and for the *LandValue* of TRZ not eligible and commercial parcels. *DistFreeways* exhibits positive mean GWR coefficients of greater magnitude for the *TotValue* and *ImpValue* of other-residential and single-family units and for the *LandValue* of single-family and multi-family parcels.
- *DistInterstate* exhibits negative mean GWR coefficients of greater magnitude for the *TotValue* of single-family and commercial properties; for the *ImpValue* of multi-family units; and for the *LandValue* of TRZ not eligible and commercial parcels. *DistInterstate* exhibits positive mean GWR coefficients of greater magnitude for the *TotValue* of other-residential units; for the *ImpValue* of single-family units; and for the *LandValue* of TRZ not eligible and commercial parcels.

This research illustrates the potential importance of allowing for spatial dependence and spatial heterogeneity in econometric models. The results indicate that GWR is a practice-ready alternative that allows visualizing the diverse spatial relationships between transportation infrastructure and real properties values. GWR confirms that the different impacts from a specific transportation facility can swing from positive to negative regardless of proximity. Benefits from a transportation facility can be capitalized by parcels even if they are not close to the facility. Furthermore, parcels located closer or adjacent to a transportation facility do not necessarily exhibit higher premia in GWR. Such is the case of *POE_DrivingTime* which exhibits lower premia for parcels located closer to the international crossings than more distant ones. In general, GWR maps can translate into better VC policy development. This represents an opportunity for regional agencies to estimate how much value is added by infrastructure projects throughout particular locations to recapture some infrastructure costs in the form of VC.

As described throughout this report, the sample data comprise a single cross-sectional dataset for 2013 allowing the identification of premia for property clusters and for individual parcels. However, it is not possible to explore how the relationships between property values and transportation infrastructure change over time. When a transportation facility is built, the real estate market capitalizes such benefits, positive or negative, into new equilibrium prices, which eventually impact assessed values. Future research should include calculating elasticities, adding a time dimension to the framework, and shifting the focus from estimation and hypothesis testing to forecasting. Adding a time dimension would allow incorporating time variables that impact real property values, such as bank lending practices, inflation, and local economic factors (e.g. annual property tax rates, annual net migration, etc.) whose values change over time. Spatial autoregressive approaches such as those of Anselin (1988) and spatial panel data methods similar to those of Baltagi (2013) emerge as natural candidates to advance this research. Introduction of a time dimension may allow better analysis of how relationships between property values and transportation infrastructure change over time, which is the crux of VC policy development.

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Vita

Arturo has lead teamwork to solve multiple priorities for governments and private clients in the U.S. and Mexico as well as multilateral organizations. His expertise focuses in preparing financial and economic models in the transportation and real estate sectors. His project experience includes logistic zones, airports, highways, urban transit, and railroads. Arturo has been responsible for assessing the financial viability of projects for private and municipal debt issuance; designing analytical tools to support financial planning of public-private partnerships and identifying market risks; and developing strategies and frameworks to facilitate bilateral trade and transborder operations. He has assisted private companies to optimize their freight shipping costs. A frequent speaker, author of publications and technical reports, he has acted as a facilitator of strategic discussions among government leaders in Texas for the implementation of value capture to finance transportation infrastructure.

Arturo joined the Texas A&M Transportation Institute in January 2, 2007 and he was promoted to the rank of research scientist in 2014. Prior to TTI, he worked at the Center for Transportation and Infrastructure Systems for Parisa Shokouhi and at the Laboratory of Dynamic Transportation and Urban Systems for Yi-Chang Chiu and Jorge Villalobos. Arturo currently serves as a member of the Aviation Economics and Forecasting Committee of the Transportation Research Board of the National Academies. He is a member of the editorial board of the International Journal of Econometrics and Financial Management. He sits in the board of directors of Polo with a Mission, a charitable initiative supporting community efforts in El Paso. Prior to enrolling at UTEP, Arturo helped his mother to manage Comercial ABA, a retail store in Parral Chihuahua, where he was born and raised.

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