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Modeling population patterns in New Orleans 2000-2010: a density function approach

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MODELING POPULATION PATTERNS IN NEW ORLEANS 2000-2010: A DENSITY FUNCTION APPROACH

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Abstract

Based on the 2000 and 2010 census tract data from the U.S. Census Bureau, this thesis examines the change of population distribution patterns in New Orleans in the pre- and post-Katrina eras by the monocentric and polycentric density functions. The study area is the mostly urbanized part of the New Orleans Metropolitan Statistical Area (MSA), including Orleans, Jefferson and St. Bernard parishes. The post-Katrina New Orleans has experienced an uneven recovery reflected in the geographic disparities in population change. The density function approach investigates what function best captures the population density distribution, how the density patterns have changed over time, how many significant centers can be identified in the study area, and how influential each center has been on the population distribution throughout the area. The regression results of the monocentric model show that New Orleans has experienced suburbanization captured by the negative exponential density function with a lower CBD intercept and a smoother gradient in 2010 than 2000. Two subcenters are identified besides the CBD in New Orleans based on the GIS surface modeling of employment density pattern in combination of field observation. The regression results from the polycentric model indicate that the CBD has significant influence over the citywide population density pattern in both 2000 and 2010, and only one subcenter is significant in 2000 but none in 2010. This indicates that the urban structure in New Orleans has regressed from more of polycentricity in 2010 to monocentricity in 2000.

Chapter 1. Introduction

1.1 Background

New Orleans has ever been a major American port city well-marked by its mosaic of architecture, music and culture. However, because of its low-lying land and the location at the river mouth of Mississippi River, New Orleans seems to be an area with "a disaster waiting to happen" (Colten, 2005; Wolshon, 2006). It has been put in the national spotlight after the 2005 Atlantic hurricane Katrina, the costliest natural disaster in the U.S. history. The city lost over 1,800 lives to the hurricane and the subsequent flooding due to lack of infrastructure, transportation means for evacuation, and inadequate emergency responses (Qin, 2009; DeSilva, 2011).

On the fifth anniversary of Hurricane Katrina on August 30, 2010, President Barack Obama visited New Orleans and applauded the city's post-disaster recovery efforts (Quemener, 2010). However, according to the census data, the population in Orleans Parish or the City of New Orleans (i.e., the core area of the New Orleans metropolitan area) dropped from 484,674 in 2000 to 343,829 in 2010. Over 148,000 New Orleanians did not come back to the city because the condition in some neighborhoods remained unlivable and many did not have the financial means to rebuild their communities. Several years after the disaster, the City and its surrounding areas have experienced an uneven recovery in different parts of the region. An examination of the population distribution patterns in the pre- and post-Katrina eras is valuable not only for academic inquiry but also for possible implications in public policy.

This thesis focuses on the mostly urbanized and densely populated part of the New Orleans Metropolitan Statistical Area (MSA), including Orleans Parish, Jefferson Parish and St.

Bernard Parish. See Figure 1.1 based on the 2010 Census TIGER files (http://www.census.gov/cgi-bin/geo/shapefiles2010/layers.cgi) excluding the major water bodies such as Lake Pontchartrain and large marsh areas. The other four parishes (Plaquemines, St. Charles, St. John and St. Tammany) in the MSA are mostly rural. A parish in Louisiana is equivalent to a county in other states in the U.S. The study area is 1,768.7 square kilometers, bordered by the Lake Pontchartrain on the north and the Gulf of Mexico on the south. Census tract is chosen as the basic geographic unit for the study as it provides a sufficient number of samples for statistical analysis of population density patterns.

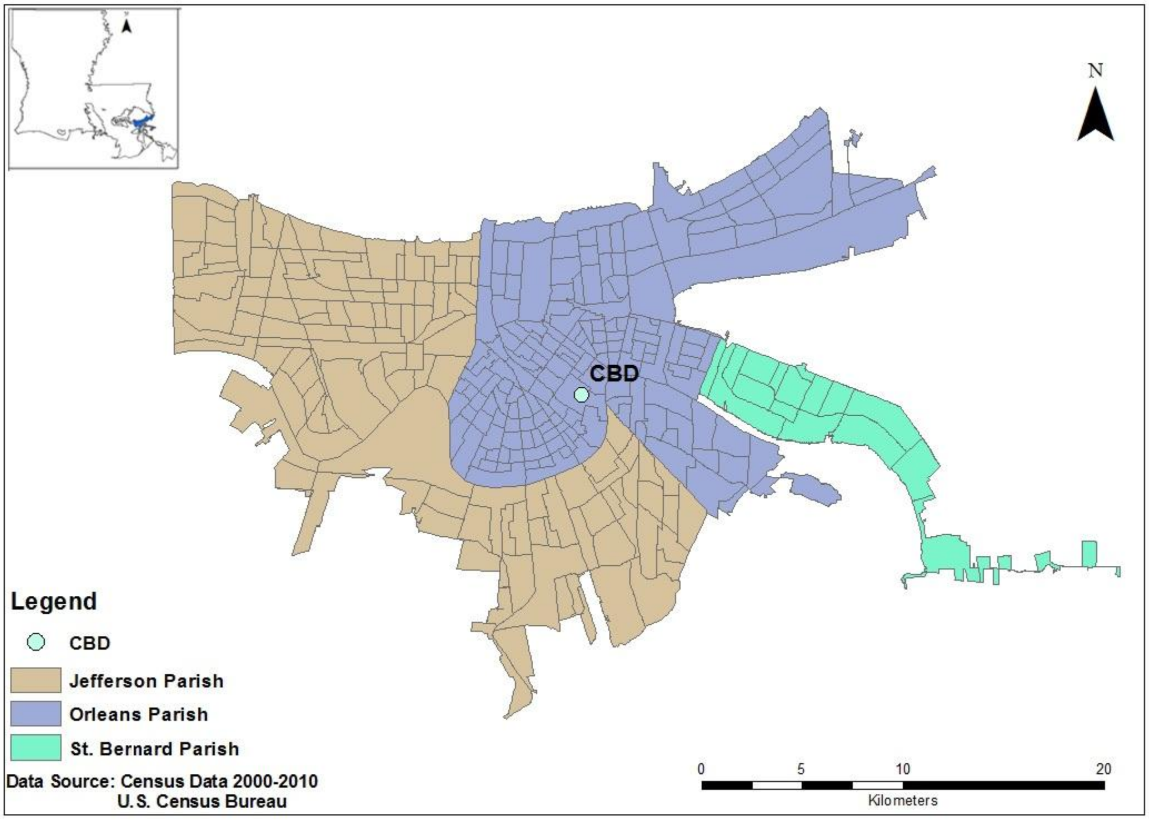

Figure 1.1 Census Tracts in the Study Area

1.2 Research Objectives

This research has two major objectives.

First, a simple area-based spatial interpolation method is used to interpolate the 2010 population data reported in the 2010 census tracts to the 2000 census tracts, based on which population change rates measured on the 2000 census tracts can be examined. With the Hurricane Katrina (2005) in the middle of two decennial censuses, the analysis of 2000-2010 population changes provides us with a glimpse of the impact of the disaster in terms of population loss and its post-disaster recovery.

Furthermore, the population density approach has been widely used in analyzing the regularity of intraurban population settlement pattern and its change such as the suburbanization trend over time. By applying the approach to the New Orleans region with its unique experience of an unprecedented natural disaster, this research attempts to inquiry several questions. What density function fits the area best? How it has changed over time? How many centers are significant in terms of their influence on the area-wide population density pattern? Have the influences of some centers strengthened or weakened over time? Has New Orleans followed the trend of most North American cities of becoming increasingly polycentric?

Chapter 2. Literature Review

Despite its cosmopolitan reputation and numerous attractions, the economy of New Orleans has been on a steady decline for more than a century (Vigdor, 2008). The Hurricane Katrina delivered another devastating blow to its already struggling economy. The City of New Orleans on July 1, 2005 before the Katrina had an estimated population of 454,863 (U.S. Census Bureau, 2008). For the city alone, more than 400,000 residents were displaced by the hurricane on August 29th, 2005 (Geaghan, 2011). Its effect was amplified by the increasing encroachment of human settlement into high-risk low-laying lands (Zaninetti, 2007). In the post-Katrina era, taking the Lower Ninth Ward as an example, residents have shown a strong culture of resistance and community resilience, and many have returned to rebuild and renew their community (Giancarlo, 2011). However, even after several years of recovery, the 2010 Census reported a population of 343,829 people in the city, i.e., a decline of almost 25% from 2005. There is an ample of studies examining the loss of population and properties due to the disaster and the post-disaster recovery efforts. However, according to my knowledge and search of existing literature, none has employed the population density function approach to examine the urban structure of New Orleans and the differences before and after the disaster.

Since the classic work by Clark (1951), population density functions have been widely used as an effective way to capture urban and regional spatial structure. McDonald (1989, pp.361) considered the population density pattern as “a critical economic and social feature of an urban area.” A population density function illustrates how population densities in different areas of a city vary (generally decline) with their corresponding distances from the city center(s). Earlier studies, including both theoretical such as the urban economic model by Muth (1969) and Mills (1972) and empirical work such as those reviewed by McDonald (1989), assume a *monocentric* structure that a city has only one center in the Central Business District (CBD). The monocentric model emphasizes that the primary center in the CBD has a strong effect upon on the population distribution throughout a city, and population densities are the same in a concentric ring at a certain distance from the city center.

The monocentric model is an oversimplification of urban structure. Since 1970, most researchers recognize that cities have become increasingly *polycentric* (Ladd and Wheaton, 1991; Berry and Kim, 1993). In addition to the major center in the CBD, most large cities have secondary centers or subcenters. Subcenters in a polycentric city not only enjoy similar agglomeration economies like the CBD in a monocentric city, but also have their own notable advantages in lower commuting and land cost (McMillen, 2001). In a polycentric model, population density functions reflect that densities change with distances to multiple centers (Small and Song, 1994). The population density at any location is the result of overlapping effects of these centers. Some believe that the effects are additive, and others believe that they are multiplicative, leading to various density functions. See Heikkila et al. (1989) for a summary.

One major challenge in the density function analysis based on the monocentric or polycentric model is the identification of center(s). Different methods have been proposed to define centers (Giuliano and Small 1991). Note that the density function approach is to examine the influence of centers on the variation of population (residential) density. The underlying assumption is that people value the access to the centers because of concerns of commuting costs to workplace or transportation costs for access to shopping and service activities. In other words, the centers should be identified according to the concentration of employment (not population) that corresponds to land uses as destinations (not origins) of home-based trips. Whether a location qualifies as an employment center needs to account for both the density of employment and the total employment around it (Giuliano and Small 1993). Some GIS surface modeling techniques can be employed to help define employment centers (Wang, 2000; Antipova, 2010).

The analysis of population density functions has at least two implications for detecting the spatial structure and change in an urban region. Taking the exponential function (often the best fitting function for a city) in a monocentric model as an example, a lower intercept and a flatter slope are commonly observed in western cities over time (McDonald, 1989) and even some cities in developing countries (Feng et al., 2009). This change indicates that the areas close to the city center usually have lost population and the areas toward the edge have gained population, i.e., the trend of suburbanization. Based on the regression results of polycentric density functions, one can clearly identify which centers influence the citywide population density pattern, whether the influence of one center is statistically significant and whether the effect got stronger or weaker over time (Wang, 1999). In other words, the results suggest if indeed a city has become increasingly polycentric or not.

Chapter 3. Data Sources and Processing

This thesis uses the Geographic Information Systems (GIS) technology to integrate spatial (geographic) and demographic data, measure spatial variables such as distance and area size and conduct spatial analysis. Specifically, ArcGIS by the ESRI (www.esri.com/software/arcgis) is used to process and analyze the spatial data. The following sections describe each dataset used in this study and how it is processed.

3.1 The DEM Data

The geographic pattern of population settlement is foremost influenced by our physical environment. For this research, elevation is of particular importance as low-laying lands are more vulnerable to flood threat. The elevation data in the raster format for the three parishes (Orleans, Jefferson and St. Bernard), specifically the *Digital Elevation Model (DEM) data set* with a resolution of 30 meters, is downloaded from the U.S. Geological Survey (USGS) web site (http://www.usgs.gov/). The DEM data set is first transformed into a projected coordinate system (using the projection "NAD_1983_UTM_Zone_15N") consistent with other geographic data sets, and then "clipped" to the study area. Based on the DEM data, the elevation ranges from -4.7 meters to +12 meters in the study area with 52% of the area at or above the sea level. The average elevation is currently between 0.3 and 0.8 meters below the sea level, with some portions of the area as high as 12 meters at the base of the river levee in Uptown and others as low as 1.5 meters below the sea level in the far reaches of eastern New Orleans (Figure 3.1). Figure 3.2 displays the elevation variation along the west-east direction through the CBD. From the west edge of the study area, the elevation increases toward the Mississippi levee, reaches the highest peak of more than 3.5 meters, then drops as low as 1.5 meters below the sea level at about 2-3 miles west of the CBD, increases toward the CBD, reaches another peak of about 1 meters above the sea level near the levee again, and then declines toward the ocean.

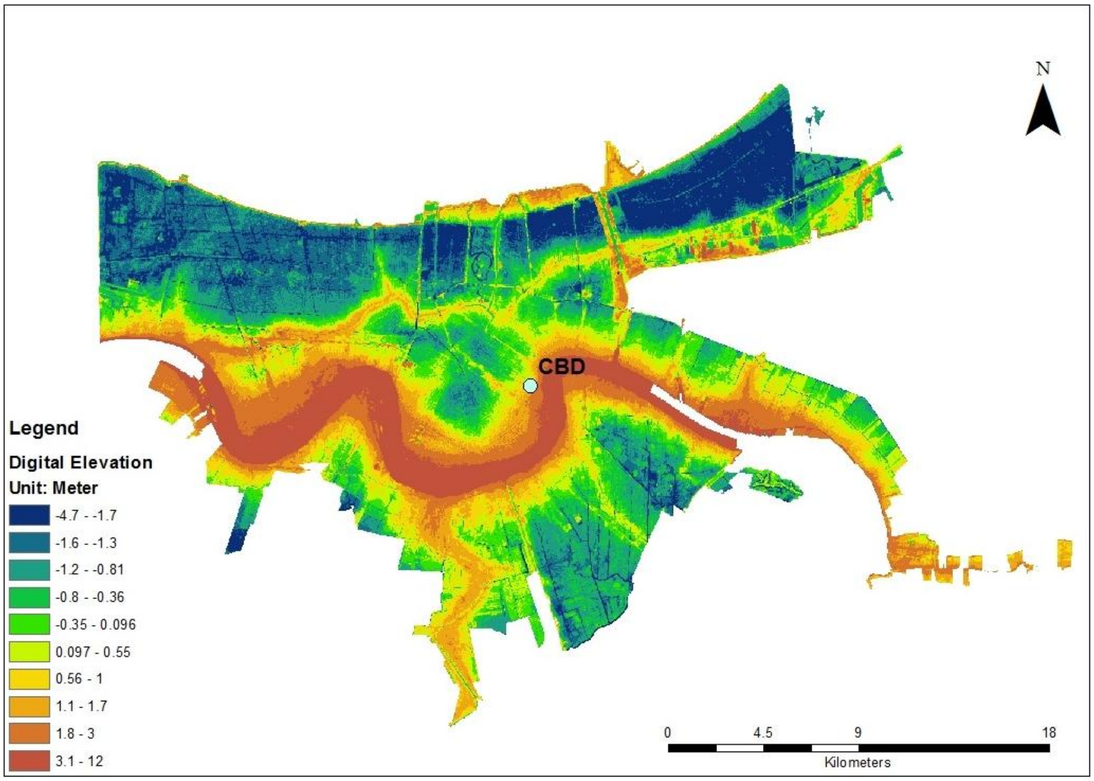

Figure 3.1 Variation of Elevation in New Orleans

Figure 3.2 Elevation Profile along the West-East Direction through the CBD

3.2 Spatial Data of Census Tracts

The census tract shapefiles (ArcGIS spatial data format) for the study area in 2000 and 2010 are downloaded from the U.S. Census Bureau's TIGER Files website (www.census.gov/geo/www/tiger/). The original spatial layers included major water and wetland areas, which were excluded to contain only the land area for subsequent area calculation and density computation. In order to improve the analysis accuracy, population weighted centroids for census tracts are derived from the population data at the census block level in corresponding years by following a tool available in ArcGIS (see Wang, 2006, pp.85). Population weighted centroid is a better representation of a census tract's location than its geographic centroid, particularly for large suburban tracts, within which the population density varies a great deal. More accurate representation of a tract location leads to a more accurate definition of distances from the centers.

3.3 Demographic Data

This study uses two types of demographic data: regular census data (by residence) for defining population, and the Census for Transportation Planning Package (CTPP) data (by workplace) for defining employment. The population data (including total population and population by major racial-ethnic groups) at the census tract level in 2000 and 2010 are downloaded from the census web site (www.census.gov). One unique feature of the CTPP data is the data by workplace in its Part 2 component, which can be used to define employment at a fine geographic resolution (census tracts for the study area). Specifically, this research uses the CTPP Urban Element Part 2 in 2000 downloaded from the Bureau of Transportation Statistics (http://www.transtats.bts.gov/tables.asp?DB_ID=630). The 2010 CTPP data are not yet available for this research. Therefore, the primary (CBD) and subcenters are defined by using the employment distribution data in 2000. More detailed discussion for employment center identification is presented in Chapter 5.

Chapter 4. Geographic Patterns of Population in New Orleans in 2000 and 2010

4.1 Overview

Table 4.1 shows the population data by parish in the entire New Orleans MSA. Among the three parishes in the study area, Orleans Parish has lost population during the entire period of 1990-2010 with a 2.5% loss in 1990-2000 and a stunning loss of 29.1% in 2000-2010; both Jefferson Parish and St. Bernard Parish gained some population in 1990-2000 (with 1.6% and 0.9% increases respectively) but had a completely reversed trend with significant population loss in 2000-2010 (loss of 5.0% and an astonishing loss of 46.6% respectively). Orleans Parish has the same boundary as the City of New Orleans, and thus may be considered the central city in contrast to Jefferson and St. Bernard Parishes as suburbia. The 1990-2000 population change trend can be characterized as suburbanization (i.e., the relocation of central city residents to suburbia), consistent with a national trend. The 2000-2010 change with all three parishes losing population is certainly attributable to the impact of Hurricane Katrina. Some more remote suburban parishes (St. Charles, St. John and St Tammany) experienced population growth throughout 1990-2010, and reflected the strong force of suburbanization in effect. The total population in the metropolitan area increased in 1990-2000, and declined in 2000-2010.

Table 4.1 Population by Parish in the New Orleans MSA 1990-2010

	Orleans*	Jefferson*	St. Bernard*	Plaquemines	St. Charles	St. John	St. Tammany	Metro Area Total
Census 1990	496,938	448,306	66,631	25,575	42,437	39,996	144,508	1,264,391
Census 2000	484,674	455,466	67,229	26,757	48,072	43,044	191,268	1,316,510
Census 2010	343,829	432,552	35,897	23,042	52,780	45,924	233,740	1,167,764

Note: * indicates parishes in the study area.

4.2 Geographic Patterns of Population Changes

Figures 4.1A and 4.1B show the population density pattern by census tracts in 2000 and 2010, respectively. Note that the census tracts in 2000 do not completely match those in 2010. For instance, the Mississippi River was noticeable on the 2000 census tract map, but the 2010 census tracts did not exclude the water body of the river. The average density in the study area declined from 2,966 persons per square km (later abbreviated as p/km^2) to 2,156 p/km^2, and the highest density (in a census tract near the CBD) decreased from 15,629 p/km^2 in 2000 to 14,791 p/km^2 in 2010. The area to the northeast of the CBD had high population densities in 2000, but the area shrank somehow in 2010. Some tracts at the northwest corner with moderately high population density began to emerge in 2010.

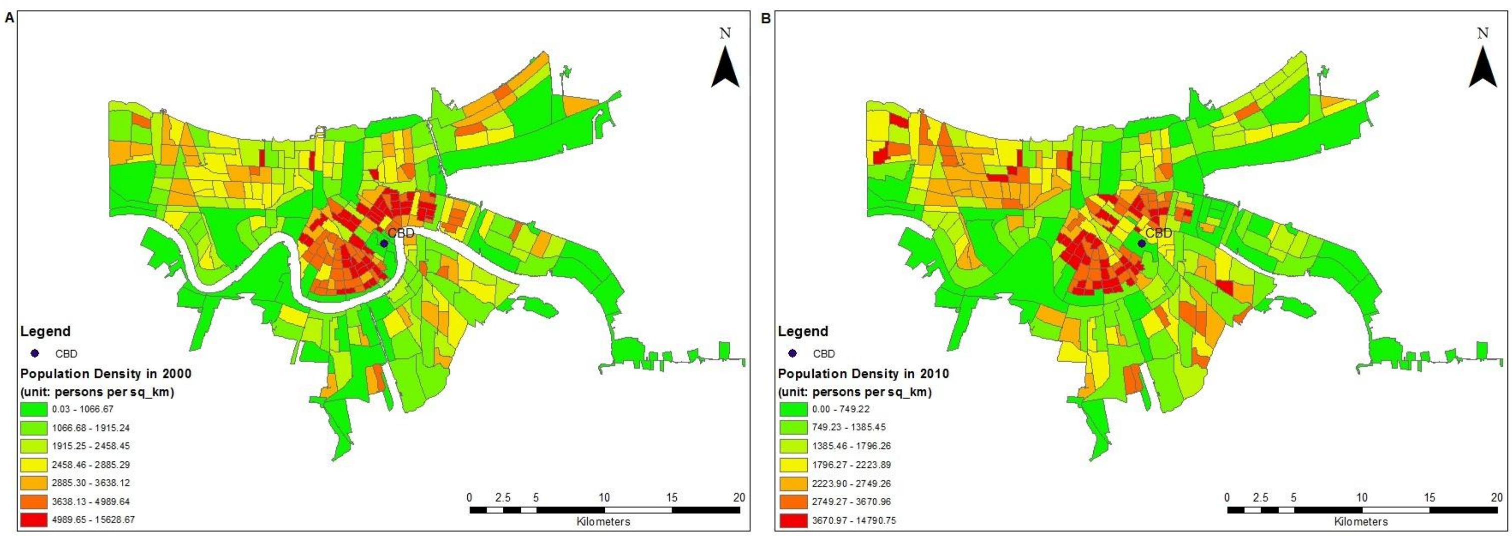

Figure 4.1 Population Density by Census Tracts in New Orleans: A. 2000, B. 2010

In order to map the geographic pattern of population density change between 2000 and 2010, one has to convert the population data in the census tracts in one year (source layer) to the census tracts in another year (destination layer) because the census tracts in 2000 and 2010 do not match each other. The transformation of data from the source layer to the destination layer is referred to as “spatial interpolation”. In this study, the simple *areal weighting interpolator* (Goodchild and Lam, 1980) is used to interpolate the 2010 tract population to the 2000 tracts. The method assumes that population is evenly distributed within each census tract and thus apportions population according to the areal proportion. Based on the actual 2000 population and interpolated 2010 population in the 2000 census tracts, the population change rates are computed on the 2000 census tracts. The result is shown in Figure 4.2.

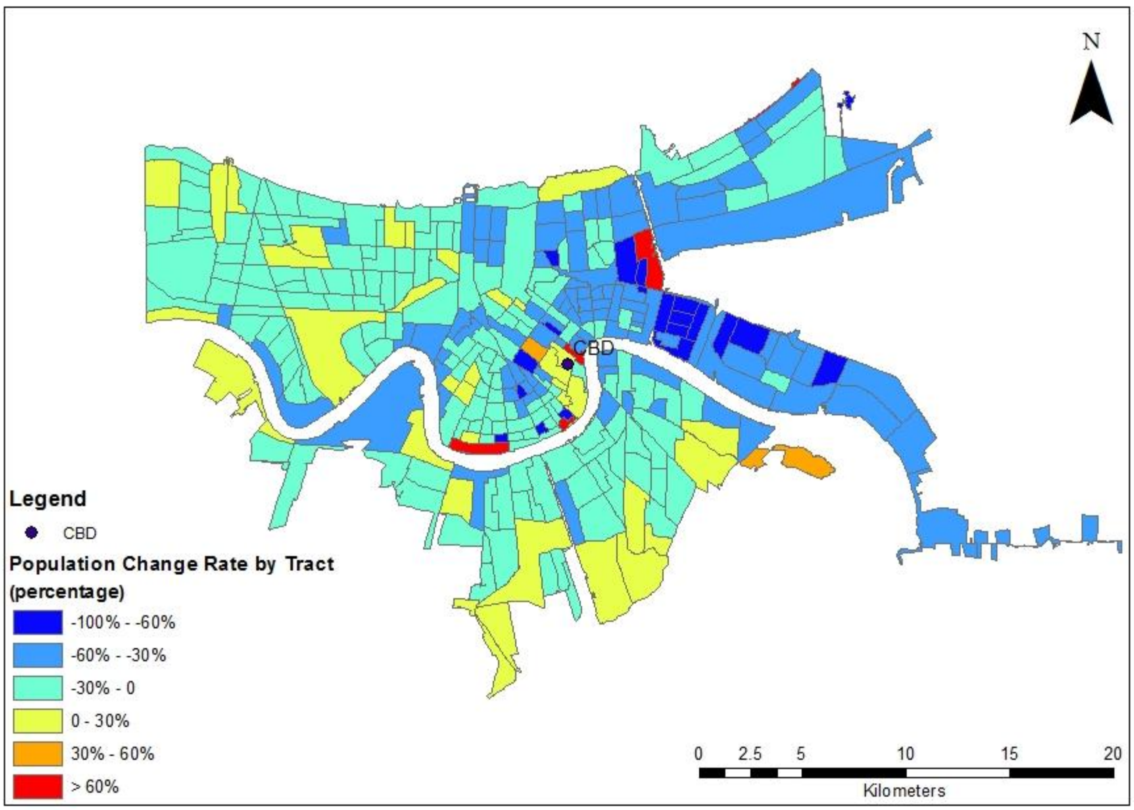

Figure 4.2 Population Change Rates, 2000-2010

From Figure 4.2, the population growth rates between 2000 and 2010 varied a great deal across census tracts. Census tracts to the east of the city center and a couple of miles to the southwest lost significant population for 2000-2010. The loss was particularly pronounced in some communities such as the Lower Ninth Ward, St. Claude, Bywater and Holy Cross. These areas are predominantly Black communities that suffered the worst damages from the hurricane and encountered major obstacles in recovery due to lack of flooding insurance and financial means. From 2000 to 2010, census tracts with population gains scattered across the study area including a few tracts adjacent to the CBD on the south, a few to the north of the River, and a dozen or so on the urban fringe in Jefferson Parish.

The GIS-based *centrographic* method is used to describe the general distribution pattern of population. Specifically, *ellipse* is used to measure how dispersed or concentrated the population is distributed around its weighted center and whether the distribution is stretched more towards one direction than others. Figure 4.3 shows that the population center of the study area migrated westward from 2000 to 2010, and the ellipses in both 2000 and 2010 were elongated mainly along the west-east direction due to the shape of the study area and settlement pattern. The westward movement of the population center is largely attributable to better recovery on the west side than the east part of the study area as shown in Figure 4.2.

4.3 Population Changes by Racial-Ethnic Groups

Table 4.2 shows the population changes by major racial-ethnic groups in the study area from 2000 to 2010. Other groups (e.g., population of American Indian and Alaska Native, Native Hawaiian and Other Pacific Islander, and others) are very small in their percentages (less than 1%) and are not discussed here. From the table, the white population accounts for about 50% of the total population in both 2000 and 2010, and thus its percentage loss is consistent with the change in general population at about 19%. For the two major racial-ethnic groups in the study area: Black population declined more than any other groups at about 25% and their share of the total population dropped from 43.6% to 40.6%, and in contrast, Hispanic experienced close to 50% increase from a share of 5.1% of total population to 9.3%. Asian population has increased slightly in both percentage share of total population (from 2.6% in 2000 to 3.4% in 2010) and population count (with a growth rate of 5.49%).

Table 4.2 Population by Racial-Ethnic Groups in the Study Area 2000-2010

	White	Black	Asian	Hispanic[1]	Total Population
2000	504,325 (50.5%)[2]	434,854 (43.6%)	25,847 (2.6%)	50,299 (5.1%)	997,680
2010	406,197 (50.4%)	326,869 (40.6%)	27,265 (3.4%)	74,809 (9.3%)	805,736
Change Rate (2000 - 2010)	-19.46%	-24.83%	5.49%	48.73%	-19.24%

Note: [1] Population of Hispanic/Latino origin or not is based a separate question from the six-type grouping (White, Black, Asian, American Indian and Alaska Native, Native Hawaiian and Other Pacific Islander, and others); [2] number in the parenthesis indicates the corresponding percentage of a racial-ethnic group out of the total population in a year.

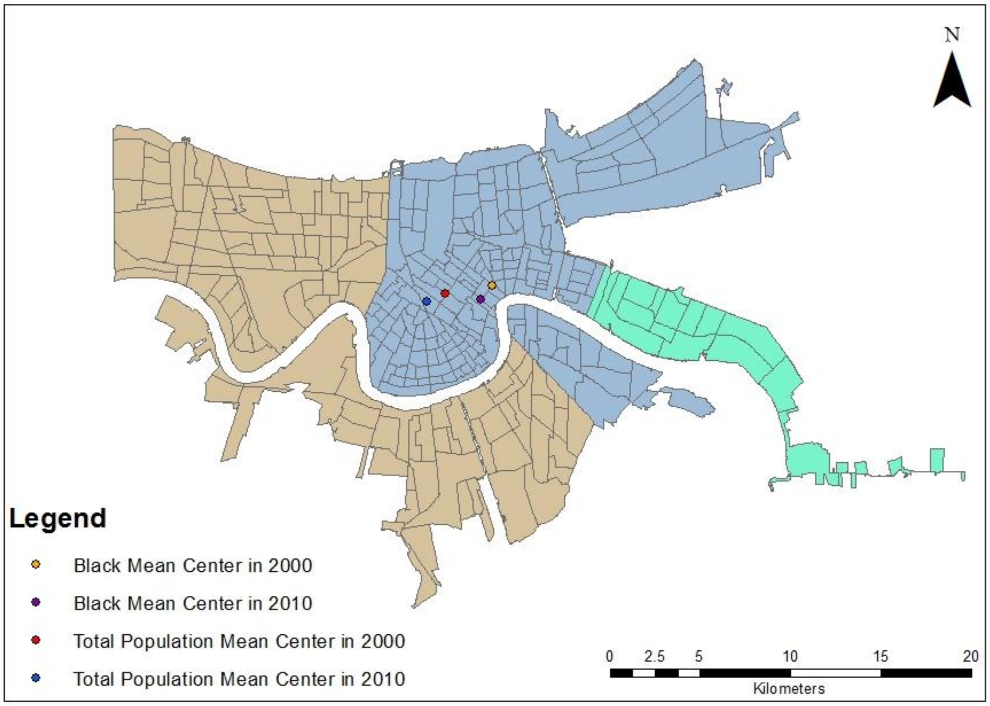

Figure 4.3 General Population and Black Population Mean Centers 2000 and 2010

Figure 4.3 shows that the Black population mean center was to the east of the general population center in both 2000 and 2010, and reflected the fact that Black tended to settle more in east part of the study area prior to the Hurricane Katrina and remained so five years after it. The migration of the Black population center toward the southwest was also largely consistent with that of the general population, but more to the south than to the west. Figure 4.4 shows that most of central city tracts lost Black population but suburban areas (particularly in the northwest and south parts of the study area) gained some. As for the Hispanic population, Figure 4.5 shows the growth throughout the study area except for the east part of the study area. However, given its small share (5%) of the total population in its base time (2000), the increases in Hispanic population count were not as impressive as their growth rates suggested. The Hispanic population mean center was to the west of the general population center in both 2000 and 2010, and also shifted slightly further westward (Figure 4.6).

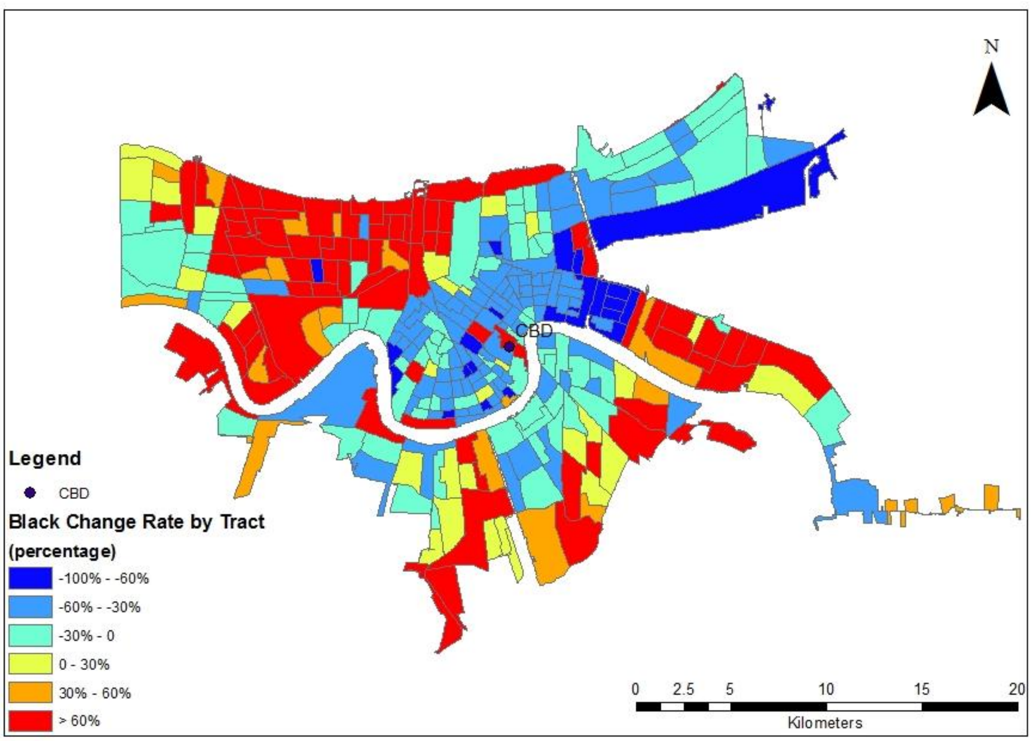

Figure 4.4 Geographic Pattern of Black Population Change Rates 2000 - 2010

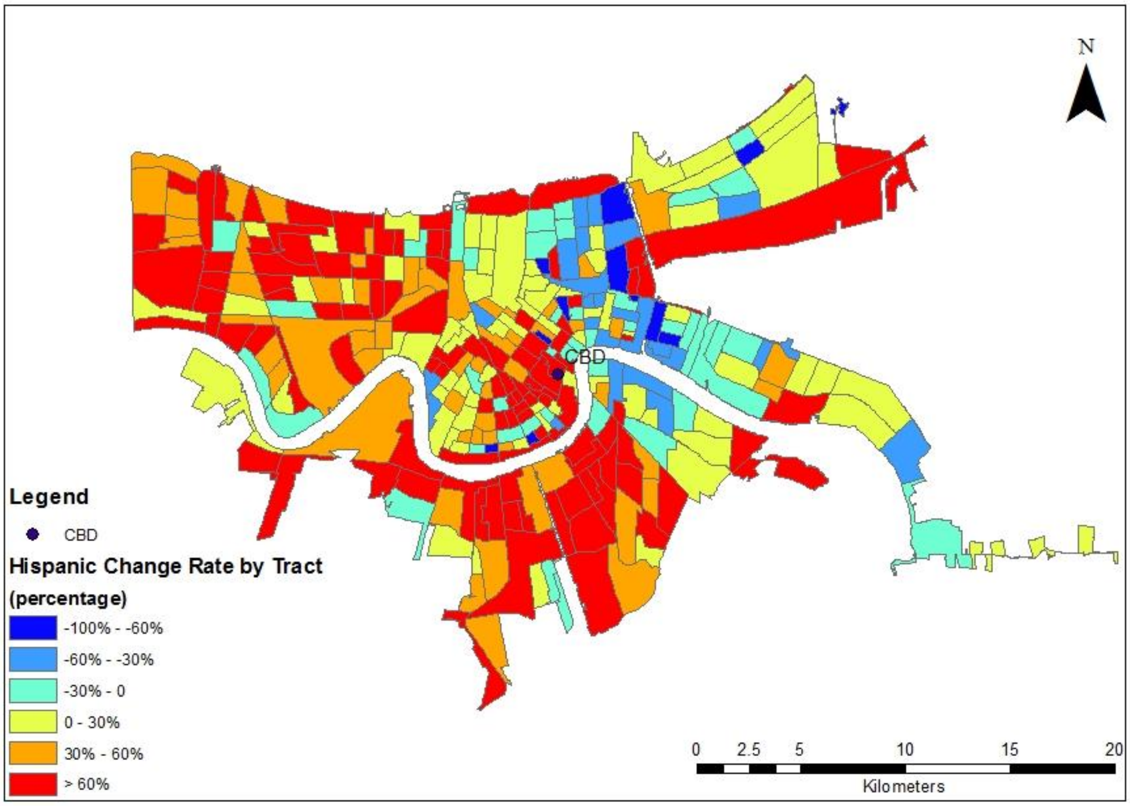

Figure 4.5 Geographic Pattern of Hispanic Population Change Rates 2000 - 2010

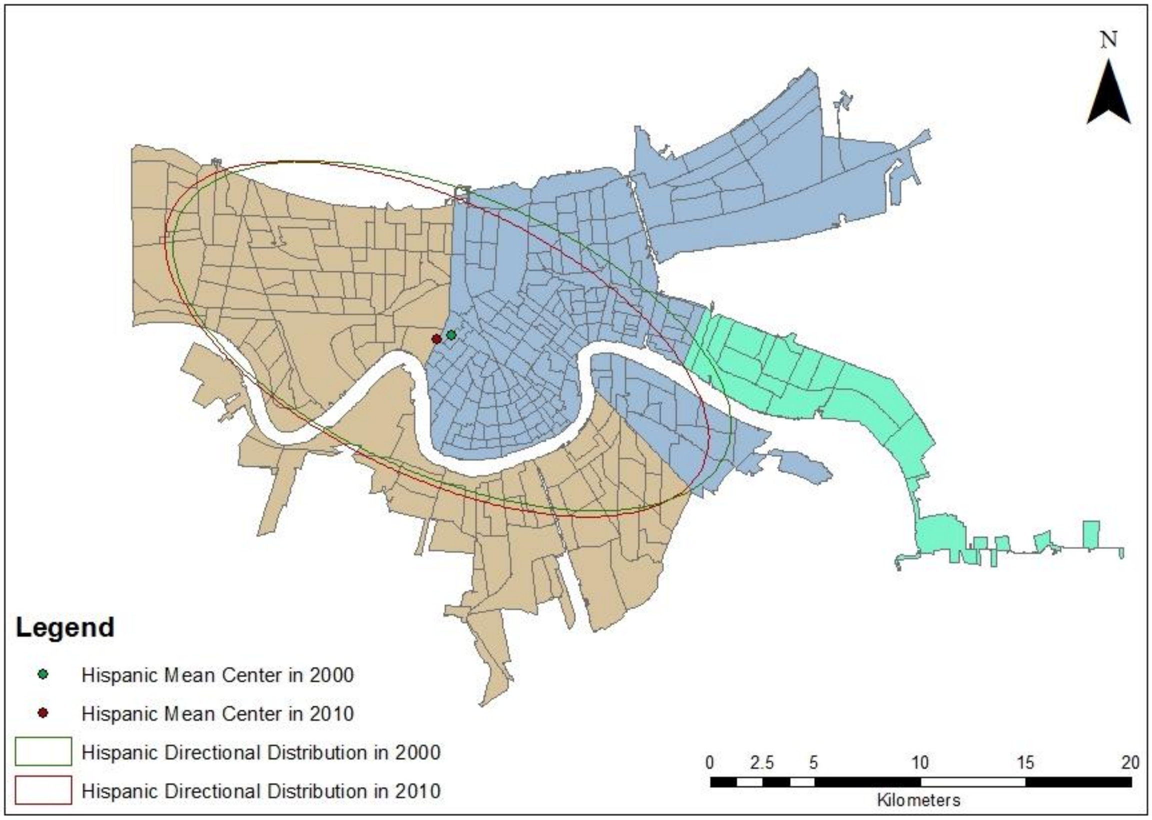

Figure 4.6 Hispanic Mean Centers in New Orleans 2000 and 2010

Chapter 5. Modeling Population Density with the Monocentric and Polycentric Functions

As discussed previously, the population density function approach is used to examine the impacts of the CBD and other subcenters on the citywide population distribution and help reveal the urban structure. In this study, the CBD is defined in the area around the commonly recognized landmark site like French Quarter area in downtown by the public and later pinpointed to a location by the analysis of employment distribution as the highest job concentration. Similarly, other centers are defined by examining the employment patterns from the CTPP data along with other sources.

5.1 Identifying the CBD and Subcenters

Identifying the CBD and other centers relies on the analysis of employment distribution pattern based on the data from the 2000 Census for Transportation Planning Package (CTPP) Part 2. Figure 5.1 shows the employment density pattern in the study area. GIS surface modeling is used to visualize the spatial variation of employment density and help identify potential job centers from the peak points of high-density areas. The definition of an employment center should account for both a density threshold and a minimum total employment (Giuliano and Small 1993). On a contour map of employment density as shown in Figure 5.2, the density threshold can be identified by an isoline. Based on Figure 5.2, 12 candidate centers are selected. These centers are indexed as 0-11 with 0 indicating the CBD and 1-11 other subcenters.

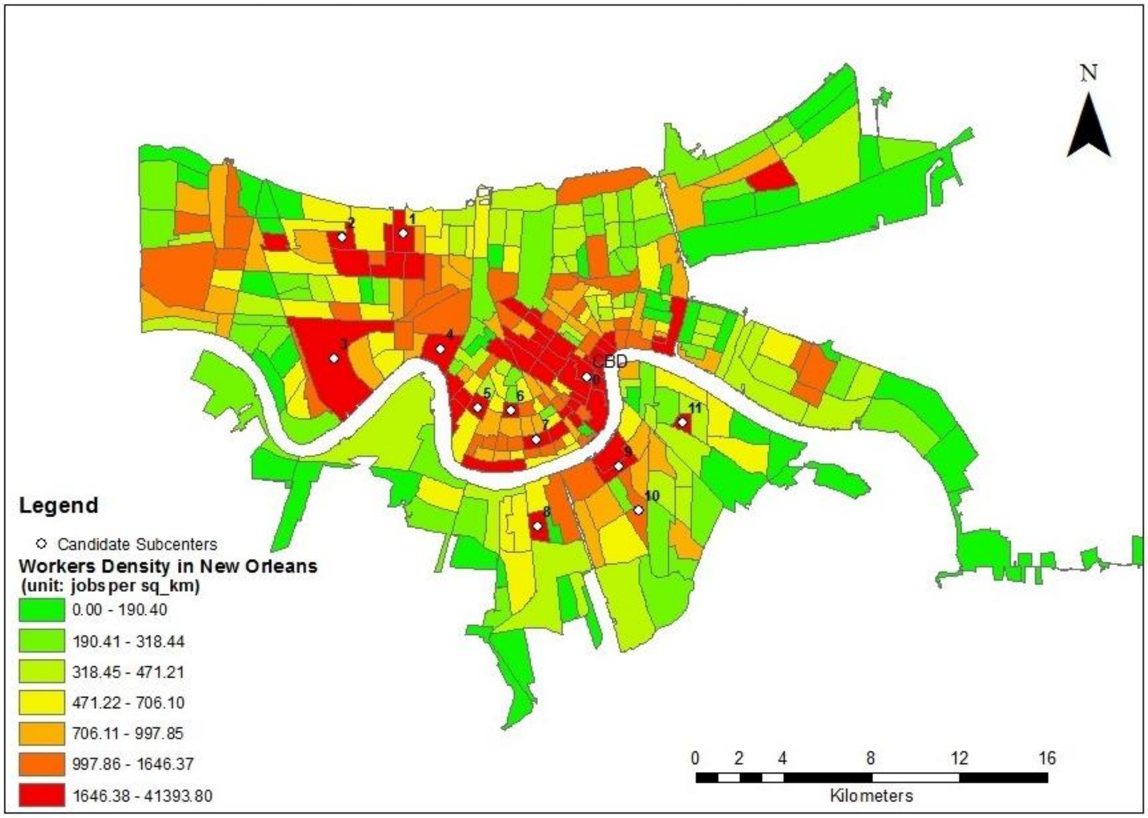

Figure 5.1 Employment Density in New Orleans 2000

Table 5.1 summarizes some basic information on these potential centers. In addition to the maximum employment density (workers per square kilometer) in a central tract, the 3rd-5th columns in the table list the total estimated employment with a 0.7-km radius, 1-km radius and 1.5-km radius from the tract, respectively. The table is ordered by the 4th column. The Google Earth is used to overlay with the potential job centers (as shown in Figures 5.3) to examine the corresponding business establishments and physical buildings on the ground. After numerous experiments, it is decided that a threshold employment density of 10,000 per km^2 and at least 10,000 jobs within 1 km are reasonable criteria to qualify as a job center. Based on the criteria, four centers with ID = 0, 1, 2 and 3 are retained as candidate centers. However, due to the proximity of centers 1 and 2, only the larger one (center 1) is retained. This leaves us with three centers: the CBD (0) and two subcenters. The two subcenters are now re-indexed as Subcenter 1 to the northwest of downtown and subcenter 2 to the west of downtown (Figure 5.4). Subcenter 1 is located at the University of New Orleans-Jefferson Campus, and subcenter 2 centers at the Abbott Laboratories. Both are major employers in the area. A previous study by McMillen (2001) also reported two subcenters in New Orleans at different locations, but that was based on the 1990 U.S. census data.

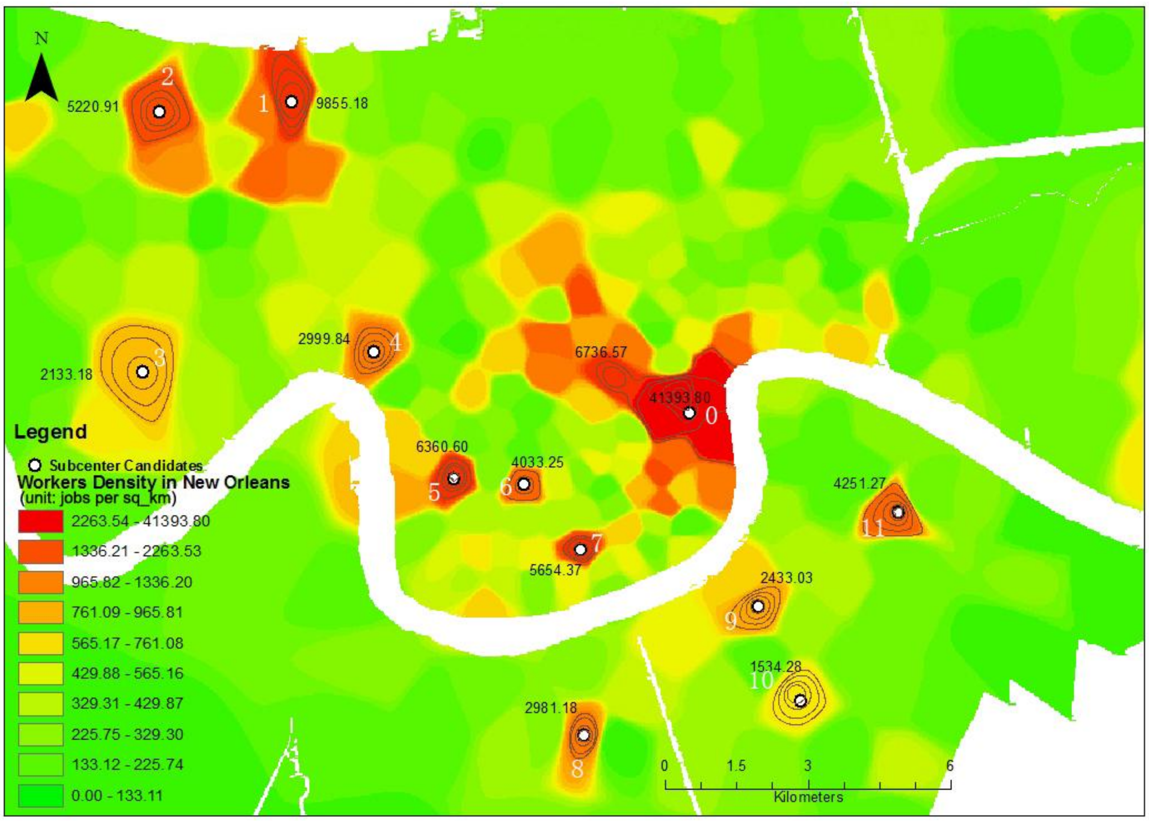

Figure 5.2 Employment Density Contours in New Orleans 2000

Table 5.1 Basic Information for Possible Employment Centers

Center ID	Maximum employment density at the central tract (per km^2)	Total employment within 0.7 km	Total employment within 1 km (Sorted by this column)	Total employment within 1.5 km
0(CBD)	41,393.80	33,880	60,870	19,412
3	2,133.18	8,080	16,490	3,907
1	9,855.18	9,334	13,420	5,154
2	5,220.91	5,487	10,487	3,009
8	2,981.18	3,586	7,319	2,011
5	6,360.60	3,467	6,367	3,654
9	2,433.03	4,912	6,192	3,822
7	5,654.31	4,274	5,649	3,507
11	4,251.27	3,015	5,578	2,557
4	2,999.84	4,744	4,645	3,396
6	4,033.25	2,655	3,703	4,058
10	1,534.28	1,458	2,976	1,455

A

B

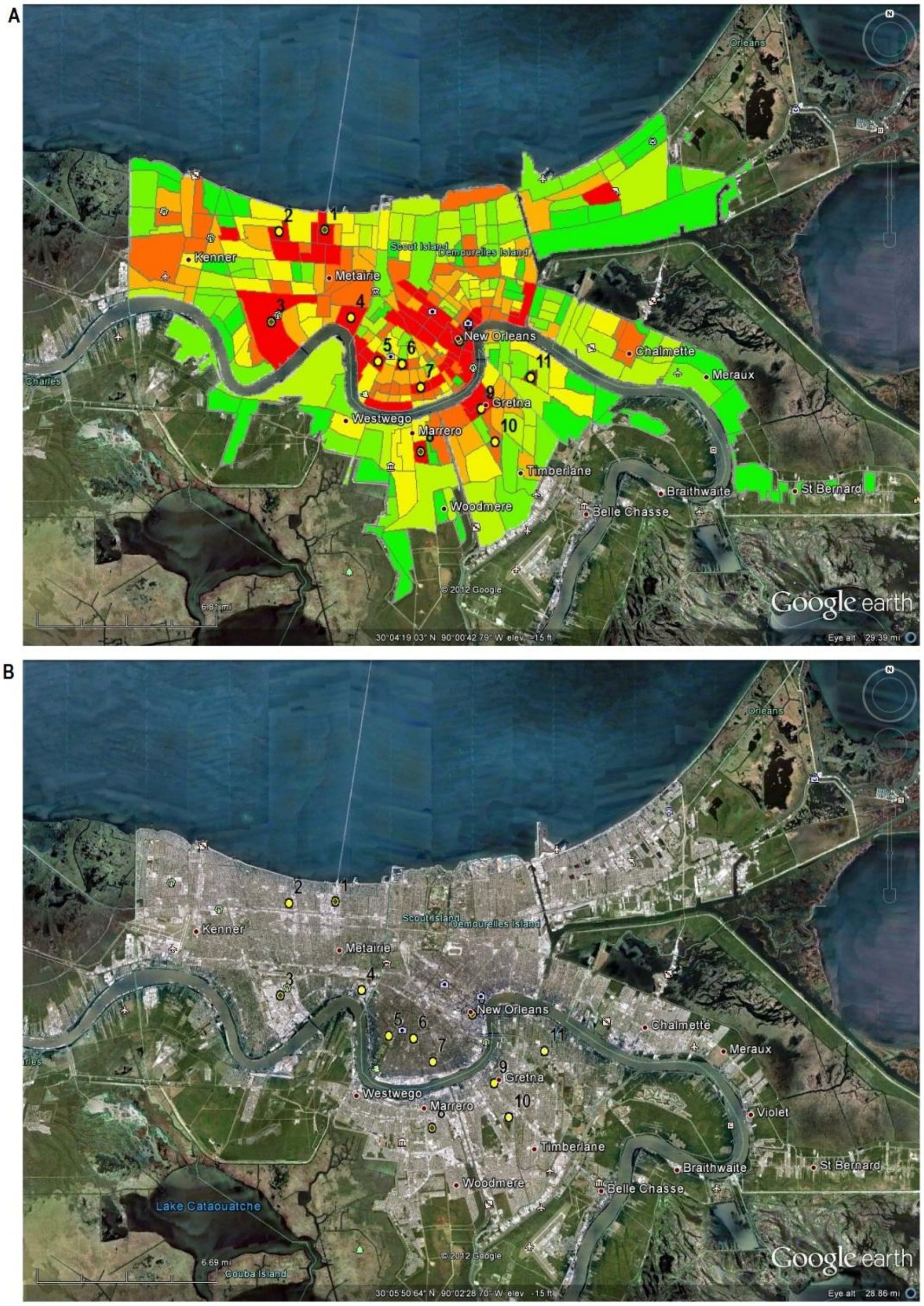

Figure 5.3 Subcenters Examined in Google Earth

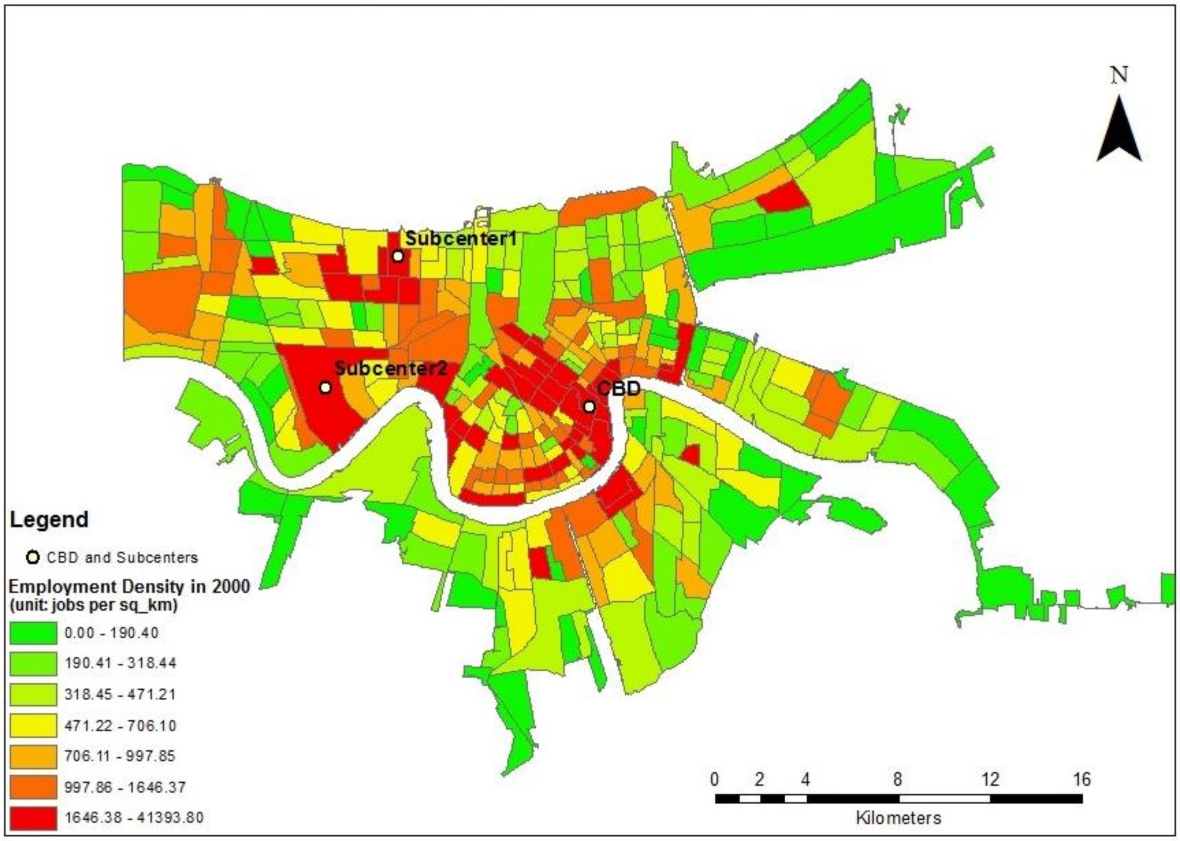

Figure 5.4 Finalized Employment Centers in New Orleans

5.2 Monocentric Model

In the monocentric model, population densities are assumed to be concentric and change with distances from the only center CBD. Various functions have been explored to test the relationship between population density (D_r) and distance (r) from CBD. The most common four bivariate functions are summarized here in Table 5.2. Results from the regressions based on the four functions are also reported in the table.

Table 5.2 Regression Results for Monocentric Functions in New Orleans

Year	Model	Regression result		
		a	*b*	R^2
2000	Linear: $D_r = a + br$	4218.4	-149.2	0.2015
	Logarithmic: $D_r = a + b\ln r$	5277.6	-1233.0	0.2134
	Exponential: $D_r = ae^{br}$	5215.8	-0.109	0.2935
	Power: $D_r = ar^b$	7269.8	-0.664	0.1698
2010	Linear: $D_r = a + br$	2838.0	-77.44	0.0192
	Logarithmic: $D_r = a + b\ln r$	3531.7	-712.8	0.1310
	Exponential: $D_r = ae^{br}$	2931.2	-0.088	0.0775
	Power: $D_r = ar^b$	3887.0	-0.550	0.0388

According to Table 5.2, the fitting power in R^2 by various functions all appears to be low (all smaller than 0.30), and even lower in 2010 than 2000. While the fitting power of the monocentric functions is subpar, the models are nevertheless statistically significant. In other words, the pattern of declining population density with distance from the CBD is largely valid, much stronger in 2000 than 2010.

Figure 5.5A and 5.5B show how the density pattern is fitted by an exponential trendline in 2000 and 2010 respectively. Consistent with the findings from the literature (McDonald, 1989), the exponential function had the highest R^2 among the four functions in 2000, and its fitting power decreased from R^2= 0.2935 in 2000 to 0.0775 in 2010 (its R^2 value is even slightly lower than the logarithmic function). Based on the exponential function, the intercept *a* decreased from 5215.8 in 2000 to 2931.2 in 2010, and the density gradient *b* (in absolute value) decreased from 0.109 in 2000 to 0.088 in 2010. A lower value of intercept indicates declining densities around CBD in New Orleans, and a smaller (flatter) density gradient reflects that densities decline more slowly (gradually) with increasing distance from the CBD in 2010 than

2000. This trend can be further highlighted by Figure 5.6, which illustrates the general trend of population loss in the central city and population growth in suburbia, commonly referred to as “suburbanization”.

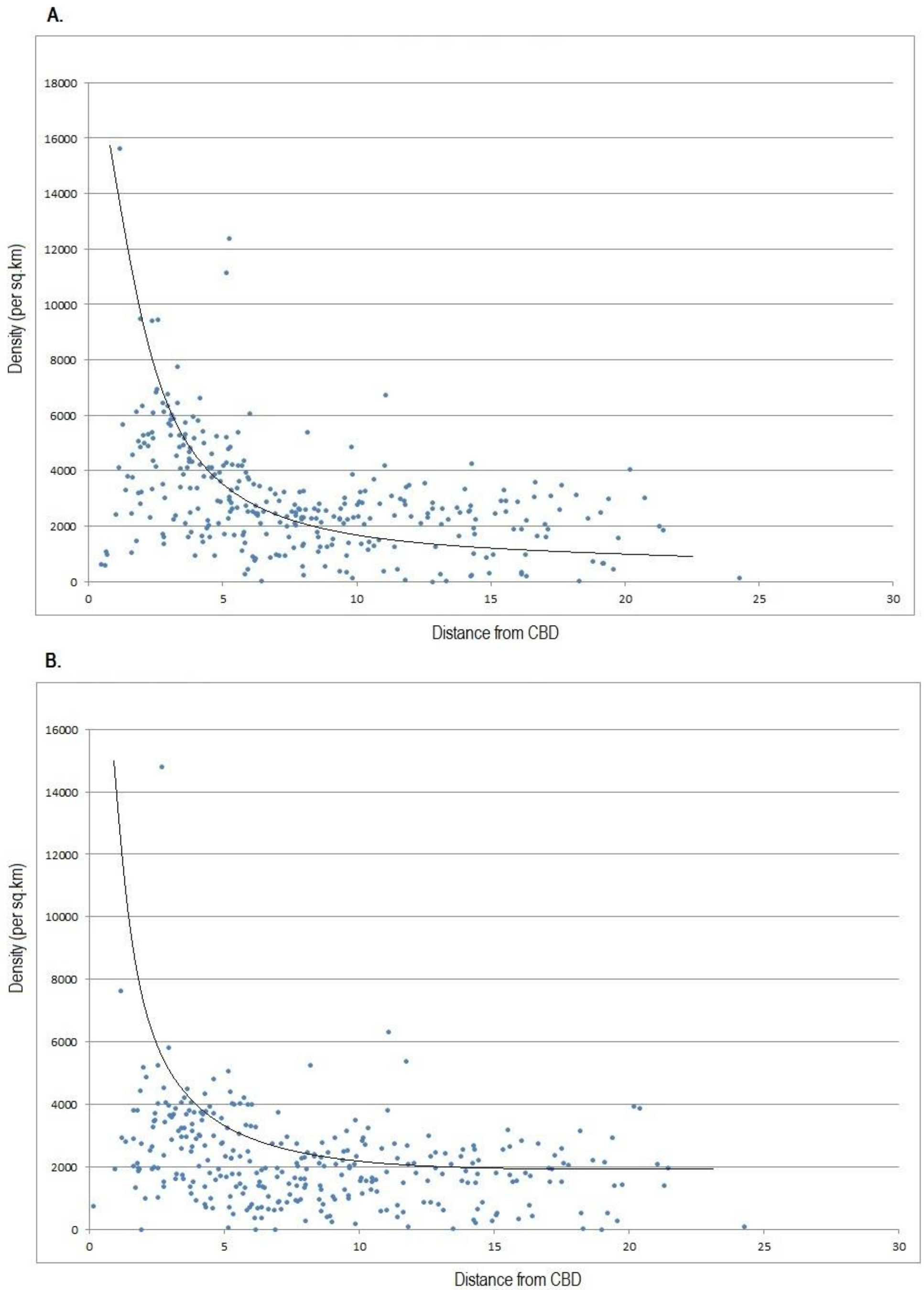

Figure 5.5 Population Density versus Distance from CBD Fitted by the Exponential Function: (A) 2000, (B) 2010

The poorer fitting power by the monocentric functions in 2010 than 2000 is consistent with the finding reported in most literature (McDonald, 1989). However, the R^2 dropping to as low as 0.13 even in the best-fitting function in 2010 and a lower fitting power by the exponential (R^2=0.0775) than the logarithmic function (R^2=0.131) in 2010 are somehow abnormal among findings reported on western cities. Evidently, the 2005 Hurricane created a great disturbance to the population settlement pattern in the area, and five years of uneven recovery were not enough to bring back the area that resembles to a "normal" density pattern. The trend of suburbanization suggested both by the descriptive analysis in the previous chapter and by the density function approach here may be a combination of (1) national trend so common to most of the North American cities and (2) the uneven recovery particular to the case of New Orleans (e.g., some suburban areas are on a higher ground and suffered less damage than the central city). It is hard to isolate one from the other and identify which force is more significant.

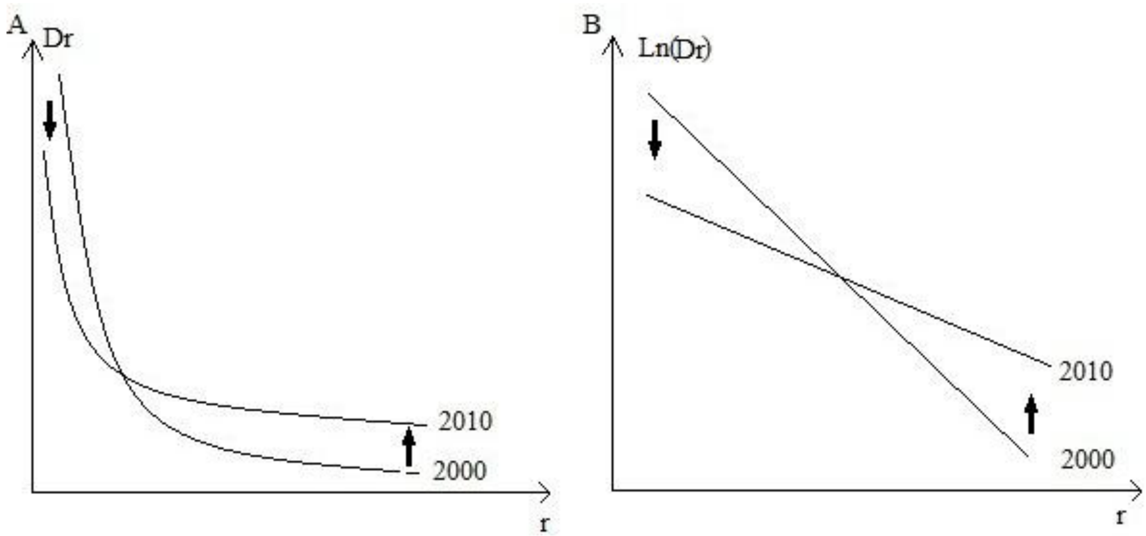

Figure 5.6 Illustration of Population Density Changes: (A) Density vs. Distance, (B) Logarithm of Density vs. Distance

5.3 Polycentric Model

This section examines the density functions that correspond to the three polycentric assumptions proposed by Heikkila et al. (1989):

(1) The first emphasizes that residents only value the access to their nearest center and a city is made up of multiple monocentric sub-regions. The underlying assumption is that the effects from these centers are *completely substitutable*. In implementation, the study area is first divided into several sub-regions, each of which is made of census tracts around their nearest center (i.e., proximal area); then monocentric density functions are estimated in each sub-region. Using the exponential function as an example, the density function within each sub-region is written as:

$$D_{r_i} = a_i e^{b_i r_i} \quad (i= 1...n) \qquad (1)$$

Or in its logarithmic transformation such as:

$$lnD_{r_i} = A_i + b_i r_i \quad (i= 1...n) \qquad (2)$$

where r_i is the distance of a tract from center *i within the sub-region i*, D_{r_i} is the population density of that tract, *n* is the number of centers, and A_i (=lna_i) and b_i are parameters to be estimated by a bivariate regression.

(2) The second assumption asserts that the influences of all centers are *complementary* and access to all centers is needed (McDonald and Prather, 1994). Therefore, density at any tract is the result of the *multiplicative* effects of all centers. Again, using the exponential function as an example, the model is expressed as

$$D = ae^{b_1 r_1} e^{b_2 r_2} ... e^{b_n r_n}$$

Its log-transformation is:

$$lnD = A + \sum_{i=1}^{n} b_i r_i \quad (i= 1...n) \qquad (3)$$

where r_i is the distance of a tract from center *i within the whole study area*, *D* is the population density of that tract, and *A* and b_i *(i=1, 2 …)* are parameters to be estimated by a multivariate regression.

(3) Most researchers (e.g., Griffith, 1981; Small and Song, 1994) believe that the influences of the centers are between (1) and (2), and that the density at any tract is the result of cumulative (*additive*) distance decay effects from each center. The model is written as

$$D = \sum_{i=1}^{n}(a_i e^{b_i r_i}) \qquad (i= 1\ldots n) \qquad (4)$$

where *D*, r_i and b_i are similar to the definitions in Equation (3), and a_i is a constant specific to center *i*. The above function needs to be estimated by a nonlinear multivariate regression method.

Table 5.3 presents the regression results for the first assumption. In the sub-region (proximal area) around the CBD, the exponential density function is statistically significant to capture the pattern of declining population densities with distance in both 2000 and 2010. Similar to the monocentric model presented in the previous section, the CBD intercept dropped and the density gradient became flatter from 2000 to 2010. Note that this is based on a sub-region with a smaller sample size of 223 census tracts than the whole study area of 318 census tracts. However, the function is not statistically significant in either of the two sub-regions around the two subcenters in 2000 or 2010, indicating minimal influences of these subcenters on the population density pattern around each.

Table 5.3 Regression Results for the 1st Assumption of the Polycentric Model

$lnD_{r_i} = A_i + b_i r_i$ for Center i's Proximal Area								
Center index i		2000			2010			
	No. of Samples	A_i	b_i	R^2	No. of Samples	A_i	b_i	R^2
0 (CBD)	223	8.6118 *** (74.96)	-0.1375 *** (-8.79)	0.2590	216	8.0647 *** (60.44)	-0.1051 *** (-6.00)	0.1440
1	44	7.8476 *** (69.96)	-0.0077 (-0.32)	0.0024	46	7.8411 *** (23.57)	-0.0808 (-1.13)	0.0282
2	51	7.4986 *** (28.61)	-0.0318 (-0.68)	0.0093	52	7.3234 *** (18.73)	-0.0478 (-0.69)	0.0096

Note: ***, significant at 0.001; **, significant at 0.01; *, significant at 0.05.; t-value are in parentheses.

The regression results for the second assumption are summarized in Table 5.4. The model in 2000 indicates that the population densities decline significantly with distances from the CBD as well as from Subcenter 1 across the whole study area, but tend to rather increase with distance from Subcenter 2 in 2000 (though not as significantly as the declining pattern from the CBD and from Subcenter 1). The observation of a positive density gradient from Subcenter 2 in 2000 is counterintuitive and raises suspicion of the validity of this assumption. In 2010, the model suggests that only the distance decay in population density is significant with distance from the CBD and neither subcenter seems to influence the area-wide density pattern.

Table 5.4 Regression Results for the 2nd Assumption of the Polycentric Model

$lnD = A + \sum_{i=1}^{n} b_i r_i$ for the Whole Study Area				
2000			2010	
Center index i	b_i		b_i	
0 (CBD)	-0. 06422 *** (-6.39)	A=8.75485 *** (65.25)	-0.04563 *** (-3.60)	A=8.31883 *** (49.36)
1	-0.09011 *** (-4.67)		-0.03030 (-1.23)	
2	0.03942 * (2.26)	R^2=0.2294 Sample Size=318	-0.02092 (-0.95)	R^2=0.1085 Sample Size=314

Note: ***, significant at 0.001; **, significant at 0.01; *, significant at 0.05.; t-value are in parentheses.

Table 5.5 shows the regression results from the third assumption, which is considered most reasonable. The model indicates that both the CBD and Subcenter 1 are significant in influencing the declining density pattern in 2000, but only the CBD is significant in 2010. Based on this, one may characterize that New Orleans has regressed from a dual-centric structure in 2000 to a monocentric form in 2010. As discussed in chapter 2, American cities have become increasingly polycentric. If so, the statistical significance of gradient b_i (for subcenter i) would need to increase, and more b_i's would need to be significant. This is not the case for the New Orleans area. Once again this reflects the major impacts by the Hurricane Katrina on the population pattern.

Table 5.5 Regression Results for the 3rd Assumption of the Polycentric Model

$D = \sum_{i=1}^{n} a_i e^{b_i r_i}$ for the Whole Study Area				
	2000		2010	
Center ID *i*	a_i	b_i	a_i	b_i
0	3981.44 *** (8.09)	-0.1572 ** (-3.00)	2451.20 *** (5.53)	-0.2111 * (-2.57)
1	2518.57 *** (3.70)	-0.0432 ** (-2.61)	-883.59 (-0.10)	0.0087 (0.10)
2	-1828.16 (-1.15)	-0.5262 (-0.98)	3185.91 (0.37)	-0.0209 (-0.29)

Note: ***, significant at 0.001; **, significant at 0.01; *, significant at 0.05.; t-value are in parentheses.

Chapter 6. Conclusion

Based on the 2000 and 2010 population census data, this research examines the spatial distribution of population and the changes in the New Orleans region from 2000 to 2010. The study area includes the mostly urbanized part of the New Orleans MSA, including Orleans, Jefferson and St. Bernard Parishes. Since the Hurricane Katrina occurred in 2005, the analysis of 2000-2010 population changes enables us to examine the impact of the disaster on the region and its post-disaster recovery.

Prior to 2000, the New Orleans region was already on the process of suburbanization with the loss of population in the City of New Orleans and the growth of population in surrounding suburban parishes. During 2000-2010, all three parishes in the study area experienced loss of population as a result of the impact of the Hurricane Katrina. However, Jefferson Parish was able to recover most of its loss of population in the post-Katrina era. An examination of population change at a finer geographic resolution such as the census tracts reveals that it is mostly the areas of low elevation (particularly those dominated by Black) that experienced the slowest recovery. The uneven recovery with more population loss in the east part of the study area than the west led to the population mean center shifting westward.

This research uses the population density function approach to examine the impacts of the CBD and other subcenters on the population distribution throughout the study area. The 2000 CTPP data is used to map the employment distribution pattern and help identify the CBD and two subcenters. One subcenter is at the University of New Orleans-Jefferson Campus, and another at the Abbott Laboratories. The regressions based on the monocentric exponential function yield a lower intercept and a flatter density gradient in 2010 than 2000, indicating a general trend of population loss in the central city and growth in suburbia. This is attributable to a combination of a continued process of suburbanization that began well before the Hurricane Katrina and the uneven recovery from the disaster with a suburban advantage. The regression results from the polycentric model indicate that the CBD has significant influence over the citywide population density pattern in both 2000 and 2010, and one subcenter is significant in 2000 but none in 2010. In other words, the New Orleans region has regressed from a polycentric structure in 2000 to a monocentric one in 2010, in contrast to most of the North America cities. This signifies another major impact by the Hurricane Katrina.

Several limitations of this study need to be pointed out. As discussed in Chapter 3, the CTPP for 2010 is not available for this research, and thus the employment centers are identified solely from the 2000 data. Although my fieldwork did not indicate any significant new employment centers emerged in New Orleans in 2010, this can be only verified by updated employment distribution data. Furthermore, the study is limited to the analysis of population density patterns and changes by the density function approach as it focuses on detecting possible changes in urban structure. It will be interesting to investigate what factors (including physical environments such as elevation and distance from the coast and socio-demographic structure) may help explain the disparities of population recovery. Both are important topics for future research.

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Vita

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