

GROWTH EFFECTS OF URBAN-RURAL AND INTRA-REGIONAL LINKAGES ON
COUNTIES AND COMMUNITIES IN THE U.S.

BY

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DISSERTATION

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Abstract

This dissertation investigates the population growth effects of urban-rural and intra-regional linkages in the United States. This dissertation follows the three paper format. The first paper (Chapter 2) investigates the construct reliability of a nodality-based spatial structure scheme for U.S. metropolitan regions. Using a broad literature review of the relationships between monocentrism, polycentrism, and economic and demographic variables, I develop hypotheses regarding theoretical characteristics of monocentric and polycentric regions. I test these hypotheses using data from regions defined by the nodality-based spatial structure scheme as monocentric or polycentric. In general, I find that while the drivers of monocentricity are well understood in the literature and are reflected in the empirically classified monocentric regions, our theoretical understanding of and our ability to detect polycentricity are not as robust. This underscores the need to investigate further the growth effects of urban-rural and intra-regional linkages. In the second paper (Chapter 3) I investigate the growth effects in non-metropolitan places of growth in proximate Metropolitan Statistical Areas. This chapter concludes that while commuting plays a critical role in delivering the benefits of urban growth to non-metropolitan places, economic linkages and commodity flows likely play a much more significant role. Additionally, there is evidence that non-metropolitan places develop to suit the demands of the nearest city, rather than participating in more global markets, though much future work could be done in this area. In the third paper (Chapter 4) I investigate spatial heterogeneity in the relationship between commuting and migration in a broad region around Chicago. This chapter supports earlier research findings that population deconcentration is driving the spatial expansion of economic activity, but that the drivers of that deconcentration vary significantly across space.

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Table of Contents

Chapter 1: Introduction.....	1
1.1 Theoretical Context of the Research.....	3
1.2 Empirical Context of the Research.....	9
1.3 Conceptual Layout of the Dissertation.....	12
1.4 Bibliography.....	15
Chapter 2: Spatial Structure in U.S. Metropolitan Statistical Areas: Metrics and Theory.....	19
2.1 Introduction.....	19
2.2 Classifying Nodal Spatial Structure in the U.S.....	21
2.3 Spatial Structure and Theory.....	26
2.4 The Model.....	32
2.5 Results and Discussion.....	35
2.6 Conclusion.....	38
2.7 Bibliography.....	39
Chapter 3: Spread and Backwash Effects for Non-metropolitan Communities in the U.S.....	44
3.1 Introduction.....	44
3.2 Background on Spread-Backwash Concept.....	45
3.3 Empirical Specification and Data.....	51
3.4 Results and Discussion.....	56
3.5 Conclusion.....	62

3.6 Bibliography	64
Chapter 4: Detecting and Specifying Spatial Heterogeneity in Commuting Patterns	68
4.1 Introduction.....	68
4.2 Analytical Framework	72
4.3 Background.....	73
4.4 Chicago, IL MSA Study Region.....	77
4.5 Econometric Analysis	83
4.6 Data.....	88
4.7 Results.....	91
4.8 Conclusion	96
4.9 Bibliography	99
Chapter 5: Conclusion.....	105
5.1 Summary of Chapters	105
5.2 Synthesis	107
5.3 Closing	109
Appendix.....	110

Chapter 1: Introduction

In economic development planning, approaches can be broken into three broad groups: people-based, place-based, and sector- or industry-based. Each of the three has specific strengths and weaknesses, and each has been trumpeted loudly in different eras of fashion within the literature. After more than a decade of fervor for sector-based approaches to economic development (initiated most notably in Porter, 1990), there is a resurgence of place-based research (e.g. Partridge and Rickman, 2005, 2006, and 2008). The most basic, sound, underlying truth that beckons scholars back to this thread of research can be summarized easily: “The wellbeing of people in the countryside is closely inter-linked with that of their urban cousins, whether an asset or a liability” (Partridge, Bollman, Olfert, and Alasia, 2007, p. 128).

An even-handed treatment of economic development should acknowledge that there are valid, even critical factors of all three (people-, place-, and sector-based) perspectives that act in both causing and improving economic development problems. Take, for example, the empirical starting point used in Moss, Jack, and Wallace (2004): structural change in the agricultural sector had decreased the economic viability of farming households in Northern Ireland. To sustain homesteads, many households turned to commuting to mid- and large-sized cities. Their paper focuses on commuting, but an economic intervention for these households could revolve around place (improving transportation routes to major employment centers), people (starting workforce training programs for farmers), or sector (increasing investments in agricultural technology to make the industry more globally competitive).

As scholars expand their focus beyond the sector-based strategies that have dominated research, the potential to move place-based research forward is greater than ever.

Technologically, the ability to specify more complete models and spatial models of development

has advanced dramatically. For instance, where scholars were previously by technological capacity to models of single, sub-state regions, we now can model hundreds of regions simultaneously in some applications. This allows increased capacity to push toward an understanding of principles rooted in theory and generalizability. When generalized understanding is developed, then local, contextualized information can be used to better tailor the theoretically-driven models. Additionally, the menu of spatial econometrics methods continues to expand. Theoretically, the years spent focused on sector-based development enrich our ability to study place-based approaches more holistically. Today's scholars better understand the roles of education and on amenities that attract creative workers (i.e. Florida, 2002) and the roles that worker education and creativity play in making industries and sectors competitive.

In the chapters that follow, I study two key mechanisms by which counties and communities grow based on linkages to metropolitan places: spread-backwash effects and complementary-substitutive commuting. Both mechanisms are rooted in place-based theories of economic development, and both are influenced theoretically by an understanding of critical elements of sector-based development, such as the importance of investment by metropolitan companies in non-metropolitan production, attractiveness of various characteristics of cities, and the differences in education levels between places within a region. I have undertaken both based on a belief in placed-based approaches to economic development and a focus on building a research agenda using spatial econometrics and regional science methods. Additionally, I have undertaken a measurement and analysis of regional spatial structure. In the course of that analysis, I build a body of theory which is used through the dissertation and provides a measure of regional spatial structure which is incorporated in testing the two aforementioned mechanisms of population change.

The remainder of this chapter outlines the theoretical and empirical contexts for the research and provides a conceptual diagram of the dissertation. The dissertation follows in the three-paper format, with the first paper following as chapter two. By measuring a spatial structure scheme and testing its validity in a U.S. context, this paper sets up background material for chapters three and four. This was done in the belief, and seeming logic, that metropolitan regional spatial structure would clearly affect the ability of non-metropolitan residents to access cities and gain employment within them. Chapter three explores the spread-backwash mechanism of non-metropolitan community-level population growth. Chapter four studies county-level commuting over time in regard to migration in a region with a strongly heterogeneous mix of urban and rural, metropolitan and non-metropolitan parts to assess the changing nature of population change at the metropolitan fringe as the spatial extent of economic activity pushes outward. Chapter five summarizes and synthesizes chapters two through four and concludes the dissertation.

1.1 Theoretical Context of the Research

This dissertation connects two areas of research in the field of regional economic planning, regional (place-based) development policies and rural-urban interdependencies. Both areas constitute large sub-fields for research within planning. In this section I will briefly summarize the relevant research agendas of both areas as they relate to this dissertation. The theory specific to the growth mechanisms studied in the dissertation is given in each substantive chapter.

Regional Development Policies

The massive domain of economic development planning can be broken down into three sub-areas: people-, place- and industry- based development theories. I am proposing research that focuses on places and consequently on place-based development. Controversy surrounds the appropriateness of such strategies, and the arguments on either side are convincing. Consider that the whole of neoclassical economics argues against place-based policies, of which regional policy is a type, since all places will eventually converge through the market. Contrast that with the reality of places like Appalachia. This sub-section provides a brief review of the theoretical arguments for regional policies, since the justification of them underlies my proposed research.

The picture that scholars have painted of lagging regions provides multiple avenues to argue for place-based policies. Duncan (1999) and Black et al. (2005) describe lagging regions as places with selective out-migration, deterioration of public services, and in the case of Duncan (1999), not only the economic, but the social ramifications of those changes. In the case of selective out-migration, place-based policies can target places where there is excess labor, where income levels are low, or place-based amenities are few (Cumberland, 1971). All of these factors encourage selective out-migration of residents, which further decreases, in a cycle of cumulative causation, the competitiveness of a place.

Myrdal (1957) describes cumulative causation as a process in which the loss of industry causes a decrease in the tax base, after which places cannot maintain their levels of public service. As those levels decrease, more companies seek better business environments elsewhere. The provision of public services is seen as both a key component in overcoming regional poverty and an eligible target for place-based strategies. Place-based policies are necessary to combat the

place-based problems of public service provision and maintain regional competitiveness (Cumberland, 1971).

As Duncan (1999) documents, rural poverty has social ramifications as well. Duncan documents corruption and nepotism, but there are other social effects. As a community declines, the sense of place inherent in that place may also decline. One can argue that sense of place is a public good, which consequently deserves public funds to maintain (Bolton, 1992). The place-based market imperfections that cause the decline of places must be addressed through place-based strategies (Bolton, 1992).

Another social cause and consequence of rural poverty is remoteness. As Litcher and Johnson (2007) find, remoteness is linked to persistent rural poverty and social isolation that precludes the most isolated from opportunities. Partridge and Rickman (2006) also argue that remoteness and isolation are causes of rural poverty. Remoteness is a function of location; place-based problems merit place-based solutions. Concentrating economic development initiatives at isolated places reduces poverty efficiently, as there is little competition from commuters or migrants for the funds. Blank (2005) also reviews the relationship between local characteristics and development, with a discussion of the necessity of both people- and place-based policies.

Aside from the characterizations of lagging regions, there are theoretical, economic arguments for place-based approaches to economic development. New Economic Geography (NEG) can be used to argue for place-based strategies. According to NEG, externalities are linked to market size, and externalities are part of the key to economic agglomeration and divergence of regions (Fingleton and Lopez-Bazo, 2006; Krugman, 1991). Place-based strategies can help rural areas experience agglomeration and knowledge spillovers, which are critical to development in this theoretical perspective (Partridge and Rickman, 2006).

The economic arguments of cumulative causation and the Verdoorn Law (that there is a strong positive association between the growth of productivity and efficiency and the rate of growth in the scale of activities) are strong and convincing arguments for regional policies. Kaldor (1970) argues, with reference to the Verdoorn Law, that wage differences within a country are limited due to labor mobility, so efficiency wages will accrue in regions with higher productivity, thus starting a cycle of cumulative causation. This counters the neoclassical economics argument that regions will converge.

Some weaknesses of place-based policies merit noting. Some of the specific shortcomings include: aid always comes at some opportunity cost to other places, assistance can't be effectively targeted, place-based policies are always overtly political, the local public sector has to be important, the government has no concern for those they do not target, and regional policies target the average resident of the region, which may not be the appropriate target (Bolton, 1992). Based on a literature review, Partridge and Rickman (2006) point out that place-based policies “induce the disadvantaged not to migrate to localities with better employment opportunities, which creates a culture of dependency in the region” (2006, p. 12; see also Shaw, 1986).

Rural-Urban Interdependency

Within the field of regional development planning, there are several literatures that describe the importance of the linkages between central cities or cities and communities or regions. Three theories in particular seem closely related to the proposed research: central place theory, growth-pole theory, and spread-backwash theories. These three theories share the hypothesis that development beyond the central city relies on the economic power of the city.

While measuring the linkages of places to the city, this relationship is the focus of this dissertation.

Central place theory has its roots in mid-twentieth century German planning research by Walter Christaller (1966). Christaller develops a theory of central goods and their market areas, given economic rationality. Central places can be distinguished based on their traffic, market, and sociopolitical spatial patterns. The traffic principle is based on transportation lines connecting the central places, forming a linear system. Christaller's theories of market-based spatial structure are reminiscent of Losch's hexagons (1938). The sociopolitical system deals with borders between political areas, with administrative areas, and other organizational/political barriers or systems which would change the system of places. These three systems of classification overlap, making delineation of central cities technically complicated. The traffic and market systems are economic; the separation theory is political and less rational. Central place theory hypothesizes that increasing technology will boost the existing central places and call new ones into being to fulfill the increase in supply. Christaller empirically sketches a system of central places in southern Germany using measures he devises and describes, namely, the number of telephone connections beyond the national per capita rate.

Growth pole theory is generally attributed to the work of Francois Perroux. A development pole, which is related to a growth pole, can be defined as a "growth inducing unit coupled with its surrounding environment" (Perroux, 1988). The theory suggests that a propulsive industry in one location can encourage growth outward from that location. As Perroux explains, "To generalize: the dynamic enterprise exerts an induction effect upon another enterprise in a given environment for a more or less short or long period" (1988, p. 67). One of the largest criticisms of growth pole theory is that the terminology was not originally defined

clearly and was not prescriptive enough for clear implementation. Perroux and other published papers trying to clarify the nuanced differences between related terms (Perroux 1988; Parr 1999a and 1999b), but empirically these efforts never yielded clear success.

Empirically, in an effort to prove that the Appalachian Regional Commission (ARC) wasn't just pork, ARC leaders tried to implement a growth pole oriented development strategy. The politics involved in dividing development funding among 13 states, however, proved to be too much for the non-prescriptive nature of the theory. "For the sake of conformity, the Commission designated the various state-determined growth centers as regional, primary, or secondary centers" (Wood, 2001, p. 556). These didn't mean much ultimately. Just over 2/3 of all ARC counties were designated as growth centers, which was grossly out of line with theory and meant that funds were not concentrated. As one politician explained, "I don't know exactly what a growth center is, but I know there is at least one in each congressional district" (Wood, 2001, p. 556). Growth centers covered about 90% of region's residents. The strategy was eventually abandoned in 1983 after failing to arrive at a coherent means of implementing the growth pole approach.

A third literature on urban-rural dependency is the spread-backwash literature. Spread-backwash effects were outlined by Myrdal (1957) and Hirschman (1959) in the late 1950s. Generally, spread effects are the positive effects of urban proximity for communities, and backwash effects are the negative consequences of proximity. According to Hirschman, the most important spread effect is the purchase and investments of the affluent region in the outlying region. The negative (backwash) effects include migration to the more developed region, especially of the more skilled and trained workers, and weak production in the outlying region, caused by superior competition in the more developed area. At its simplest, spread and backwash

can be measured by either population change or income change as a function of distance to the nearest city. Gaile (1980) frames the evolution of spread and backwash concepts. More recent notable contributions have come from Carlino and Mills (1987) and Boarnet (1994), who explored county level income and population growth.

1.2 Empirical Context of the Research

In addition to the ARC implementation of growth pole theory, one thread of empirical research relating to intra-regional linkages is of the relationship between highways (one measure of linkages) and county-level productivity or growth (Aschauer, 1989; Chandra and Thompson, 2000; Garcia-Mila and McGuire, 1992; Rephann and Isserman, 1994). Aschauer (1989) provides some context for studying intra-regional linkages and productivity, by testing the relationship between non-military public capital stock, a core of infrastructure, and changes in productivity in the private US economy. Chandra and Thompson (2000) and Rephann and Isserman (1994) measure income change in counties that have gained highway development compared to a control group of counties. Garcia-Mila and McGuire (1992) study "the productive contribution of publicly provided goods and services, in particular, highways and education" (p. 229). Though the proposed research focuses on a different measure of intra-regional linkage (commuting), the relevancy of the findings on highway development are clear.

An empirical example of the importance of the theories of intra-regional linkages can be seen in the Appalachian Regional Commission's focus on highway development. The Appalachian Highway System (Figure 1.1), which connects rural areas to more densely settled cities, has a constant dollar economic return rate of 8.29% and has had a multiplier effect of 1.32 in the region. As of September 2006, over 2,300 miles of the Appalachian Highway System were

complete. Funding to continue building through 2009 is authorized through the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (Wilbur Smith Associates, 1998).

Isserman and Rephann (1995) provide a convincing argument that without the Appalachian Regional Commission (ARC), which is a place-based approach to development, the Appalachian counties would not have grown as quickly as they have. Cumberland (1971) and Bolton (1992) provide a summary of the arguments for and against regional policies.

Access to cities is an important fixture of the economy across the U.S. In 2000, 17% of nonmetropolitan residents commuted to central cities and suburbs, and 90% of suburban residents worked in metropolitan areas (suburbs or central cities) (Pisarski, 2006, p. 48). As it related to rural and small town development, commuting outside of the home county is most common among smaller counties (Pisarski, 2006, p. 49); intra-regional linkages are critical for these places. Commuter flows also showed strong regionality. In 2000, only 7% of central city residents and 10% of suburban residents worked outside of their home metro area. The strength of intra-regional flows thus validates the study of intra-regional linkages rather than inter-regional linkages for effects on population growth.

Appalachian Development Highway System as of September 30, 2008

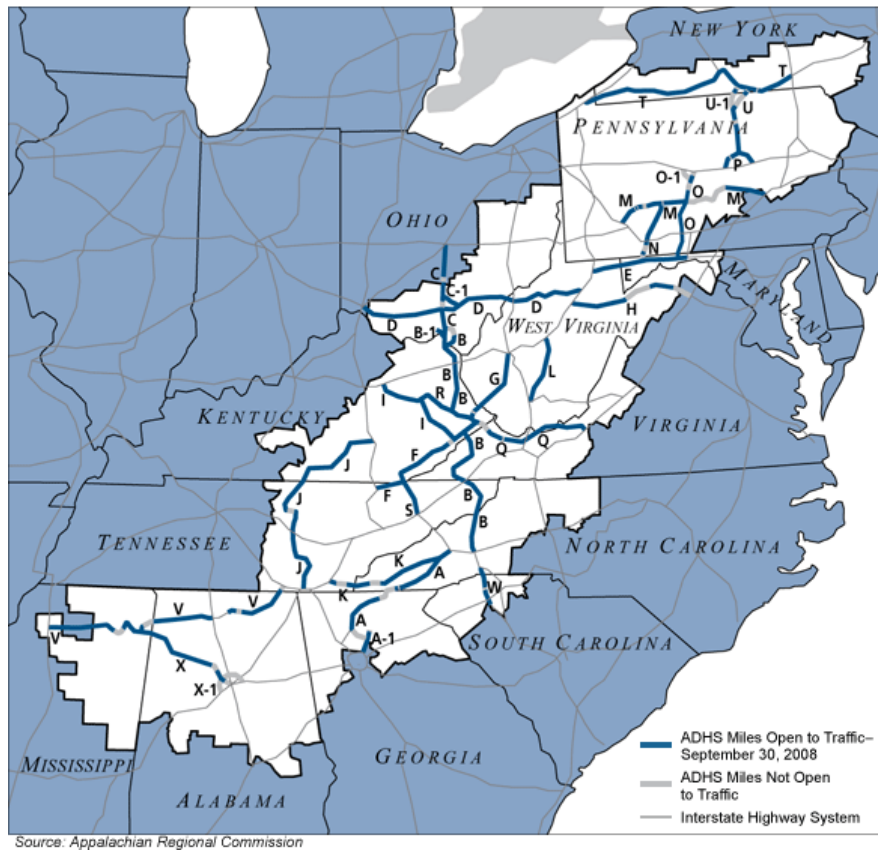


Figure 1.1: Appalachian Highway System (adapted from <http://www.arc.gov/index.do?nodeId=1006>, accessed 2/14/09)

A final empirical example to contextualize the research stems from Isserman's research on defining rural America (2002). In this research he states that of the counties that were non-metropolitan in 1970 and remain non-metropolitan, population growth has been 28%, compared to 38% for the nation. In comparison, the counties that were non-metropolitan in 1970 and were metropolitan in 2000 grew by 80%. It stands to reason that many if not most of the converted counties (non-metropolitan to metropolitan) became outlying counties in a metropolitan area, meaning, primarily, that they met certain requirements for integration via commuting to core metropolitan counties. Counties growing below the national average are probably more isolated. Development through commuting is important for the continued decline of concentrated poverty

in rural places and for exposing rural children to opportunities away from home (see Lichter and Johnson, 2007). For these isolated counties, spread effects through commuting are even more critical.

1.3 Conceptual Layout of the Dissertation

The central theme of this dissertation is reflected in its title: the growth effects of intra-regional and urban-rural linkages. The approach I take to researching along that theme is shown in figures 1.2 and 1.3, below. Figure 1.2 illustrates the overall conceptual layout of the dissertation, in all its parts.

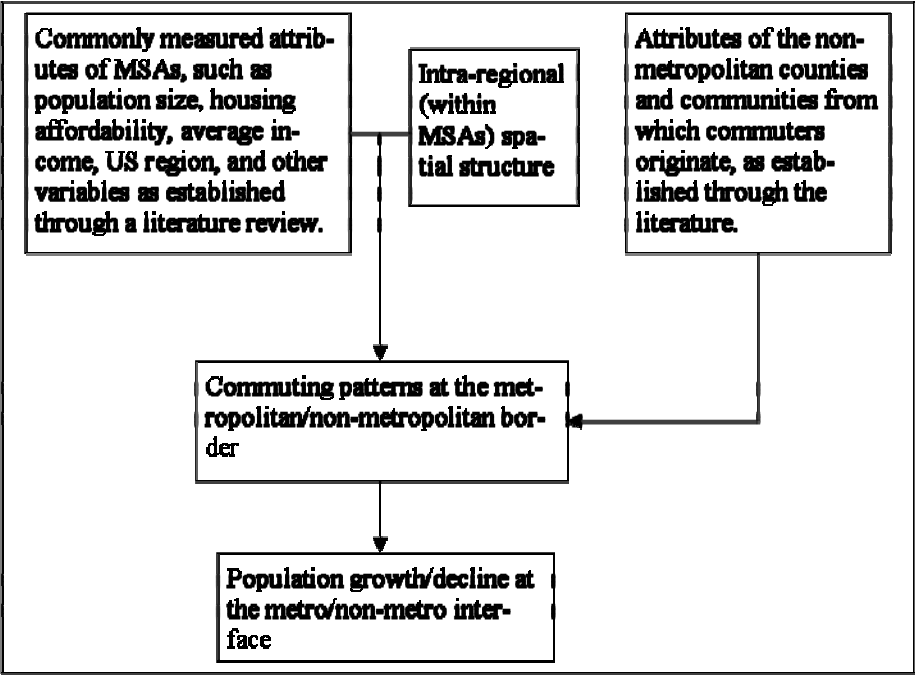


Figure 1.2: Overall conceptual diagram

Figure 1.3 (below) gives a conceptual layout for each of the three papers that make up the body of this dissertation. As briefly described in the introduction, chapter 2 measures the values of a nodality-based measure of intra-regional spatial structure for 267 MSAs/CMSAs across the

U.S. and tests its validity given a large body of theory regarding household location choice and the drivers of monocentrism and polycentrism. In chapter 3 I measure spread-backwash effects on population growth for 2,170 non-metropolitan U.S. Census designated places for the period 2000-2007. Spread effects are, in simple terms, the positive effects of urban proximity, most notably the investment in production in outlying areas. Backwash effects are the negative effects of urban proximity, including weak production and selective out-migration. My approach is novel in the geographic breadth for a U.S. study and in its focus on conceptual measurement and comparison, as well as its use of commuting data for weighting.

In chapter 4 I investigate the changing relationship between commuting and migration for a 65-county region surrounding Chicago, IL. Informally, a great amount of residential turnover and population growth has been observed at the urban-rural fringe areas within this region. Based on previous empirical work (Renkow and Hoover, 2000) and the untested observation of a concomitantly expanding spatial range of economic activity, it was thought that workers were moving from traditional suburbs into more distant suburbs and commuting to jobs that were suburbanizing to the traditional suburban areas. However, population growth and commuting have changed unevenly across space. This paper sets out to explore theoretical mechanisms and use that theory to build on the empirical modeling of the spatial heterogeneity observed in the commuting-migration relationship across the region in 2000.

Taken together, these three chapters contribute to the central theme of this dissertation, as given in Figure 1.2. Chapter 5 synthesizes the findings of chapters 2 through 4 around that theme.

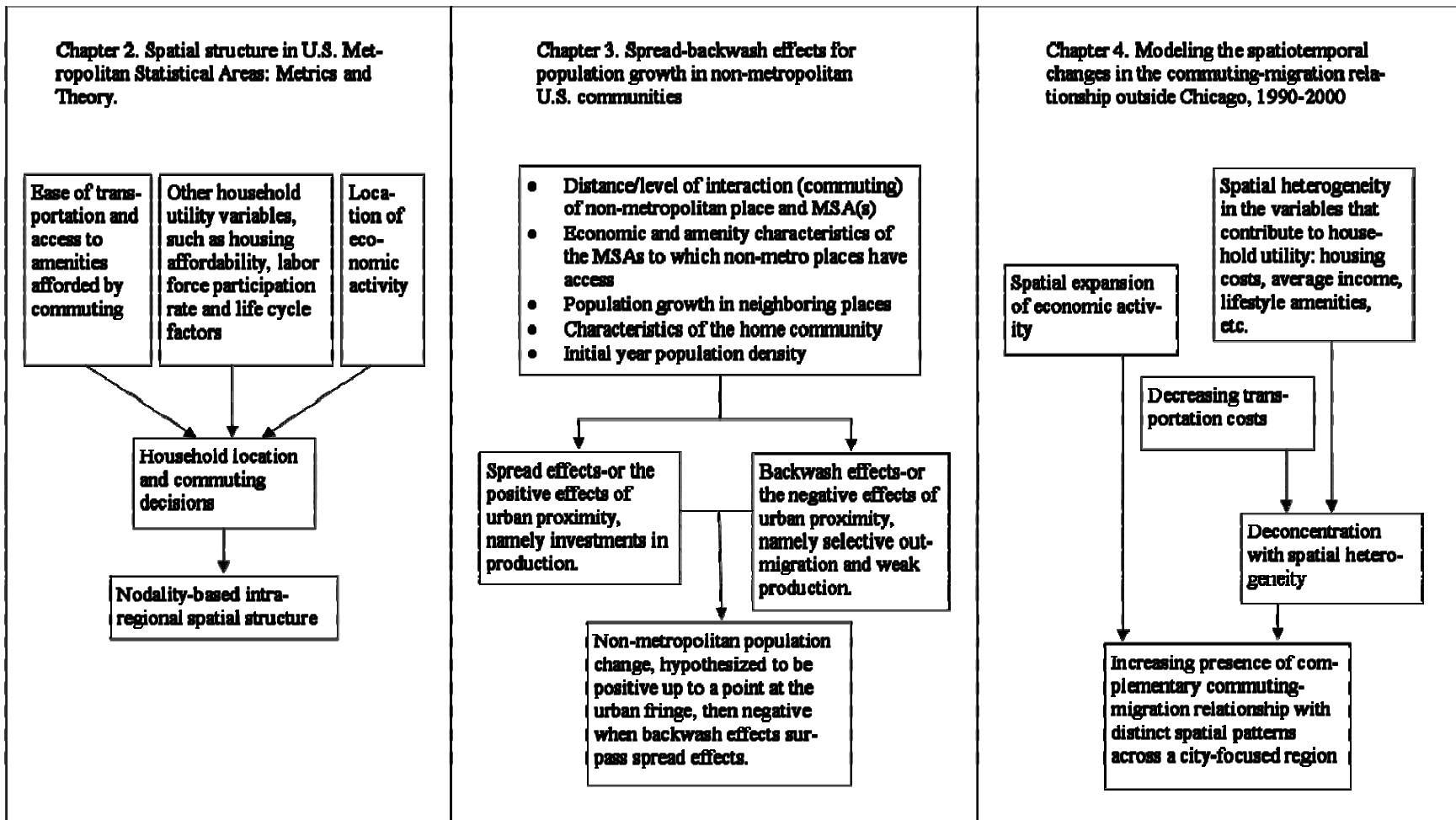


Figure 1.3: Conceptual diagrams for chapters 2, 3, and 4

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Chapter 2: Spatial Structure in U.S. Metropolitan Statistical Areas: Metrics and Theory

2.1 Introduction

Through the middle and end of the twentieth century, many Americans aspired to have an attractive home with a lawn, within reasonable driving distance to an urban center. This national ideal cultivated an image of a worker commuting from any one of a dozen identical suburbs to a region's city. In the 21st century that image is quickly changing, to an image of a region with multiple nodes, edge cities, and complex spatial patterns. Examples abound. Consider Tysons Corner, outside of Washington, DC. Tysons Corner was once a mere crossroads, then later a budding suburb of the nation's capital. Today Tysons Corner is the seventeenth largest central business district in the country. Tysons Corner has become a viable economic engine, an economic center of its own right. The irony is that Tysons Corner remains unincorporated, parts of two other towns' postal areas; we continue to treat it as a piece of land between other suburbs (Fogg, 2007). This slight is indicative of a broader failure to recognize the vast and significant changes, including economic ones that are evident in the spatial structure of regions.

As these changes have come to bear on American society, the study of spatial structure and commuting has gained popularity among social scientists. The spatial structure of regions is often measured by commute time or distance for workers originating in suburbs versus central cities (e.g. Gordon, Kumar, and Richardson, 1989), counties, Census tracts, or even block groups. Scholars have investigated a wide range of economic and social processes through the lens of spatial structure: the development of regional economies (Van der Laan, 1998), the influence of changing prosperity and employment growth on commuting (Schwanen et al., 2004), the relationship between spatial structure and transit mode choice (Schwanen et al., 2004),

the drivers of the non-metropolitan turnaround (Henry et al., 2001; Renkow and Hoover, 2000), the choice to commute or move and the subsequent socioeconomic and community development issues (Eliasson et al., 2003), the impacts of housing segregation (Gottlieb and Lentnek, 2001; Shen, 2000), and the role of planning and planning goals in influencing the commuting patterns of various groups (Rouwendal and Meijer, 2001).

Despite its importance in exploring these social and economic processes, most U.S. studies study the relationships between commuting time or distance, rather than by nodal types of spatial structure, and socioeconomic and demographic variables. This paper bridges that gap in two ways. First, I evaluate the applicability of an existing nodality-based classification scheme (van der Laan, 1998) for spatial structure to U.S. metropolitan regions (MSAs/CMSAs, henceforth collectively referred to as MSAs). Unlike most schemes, this approach pays “explicit attention to distinct differences among polycentric regions” by identifying variations in the spatial form (Schwanen et al., 2004, p. 312). If the classification system proves useful in the U.S. application, it can be extended to create a more detailed and useful classification system. One possible variation of such a taxonomy is envisioned but not produced in van der Laan’s work (1998).

Second, through multiple regression analyses, this paper tests the extent to which van der Laan’s (1998) spatial structure scheme supports existing spatial structure theory. Among existing theories is van der Laan’s assertion that “types of urban systems can be seen as stages in a development which depend particularly on changes in the economic structure” (1998, p. 241, 244). Such a finding would lend support to place-based economic development strategies, especially in transportation planning. This paper finds a relationship between spatial structure and average annual pay.

The remainder of this paper is arranged in four sections. The first section describes the spatial structure scheme used in this paper, describes the methods used to apply it to the U.S., and briefly presents the results of that application. The second section reviews theory of spatial structure and various socioeconomic and demographic variables. The third section introduces the multiple regression models and variables used to test the applicability of the theory to van der Laan's spatial structure scheme in the U.S. The final section presents and discusses the results of those models.

2.2 Classifying Nodal Spatial Structure in the U.S.

Van der Laan's classification scheme relies on the ability of the researcher to identify streams of commuters into and out of central cities using Dutch commuting data. Fortunately, similar information can be ascertained in the U.S., with some imposition of definitions, using the Census Transportation Planning Package 2000 (CTPP 2000). The method is based on flows into and out of the central city and suburbs, not all flows into and out of the city or metropolitan region. Similarly, flows originating in the central city and ending outside of the MSA are excluded. The VDL approach has the benefit of identifying not only regions with centralized or dispersed spatial structures, but also the flow of workers among the nodes within regions. The downside of this approach is that it does not reveal the number and relative significance of the nodes.

Van der Laan's typology (1998, henceforth VDL), which underlies both his own work and Schwanen et al. (2004) is mechanically straightforward. Van der Laan represents the typology in a two-by-two matrix:

Table 2.1: VDL Classification Scheme

From/to	Central city	Suburbs
Suburbs	N1: traditional commuting	cross- commuting
Central city	locally employed	N2: reverse commuting

Where:

$$\text{Nodality-1 (N1)} = (IC_C/IC_D)*100$$

Where IC_C = sum of flows from intra-MSA suburbs to the MSA's central city

IC_D = sum of flows between all places in the MSA

$$\text{Nodality-2 (N2)} = (OC_C/OC_D)*100$$

Where OC_C = sum of flows from the central city to intra-MSA suburbs

OC_D = sum of flows between all places in the MSA

$$IC_D = OC_D$$

N1 represents flows to the central city from the suburbs (defined as Census designated places that are not the central city, defined below) as a percent of all place-to-place flows. N2 is concerned with commuters who live in the central city and work in the suburbs. The sum of the

four quadrants in Table 2.1 represents all commuters that begin and end their journey to work in places within the MSA. This approach ignores commuter flows that begin or end outside of the MSA, and those that begin or end in non-places within the MSA. The flows that either begin or end in non-places are significant. For example, in the Winchester, VA-WV MSA, only 14.7% of intra-regional commuters begin and end the journey to work in Census designated places. At the other end of the spectrum, in the San Jose-Sunnyvale-Santa Clara, CA MSA, 93.7% of workers begin and end their commutes in Census designated places. The focus of the spatial structure scheme under study here is nodality, or the joint distribution of people and jobs. Areas that have workers but are not Census designated places, by definition, are not places with significant local economies. Consequently, these observations are not considered in this study. The IC_D and OC_D measures given above use the sum of flows that both begin and end in Census designated places, rather than the total sum of all intra-regional commuter flows. An extension of this work could expand Table 2.1 into a three-by-three grid, where the third row and third column are “non-places.”

Van der Laan (1998) plots regions according to scores for N1 and N2. The plot is divided into four unevenly sized quadrants, representing exchange-commuting, central commuting, decentral commuting, and cross-commuting. Exchange-commuting means that suburban residents work in the central city and central city dwellers often work in the suburbs. VDL asserts that central commuting indicates a monocentric or traditional spatial structure, where the central city attracts workers and the suburbs serve as bedroom communities. Decentral commuting implies the opposite, that suburbs attract workers from both suburbs and the central city. Finally, cross-commuting means that many suburban residents work in suburbs (not necessarily those they live in) and central city residents work in the central city. This is a type of

intra-regional dual labor market, meaning that there are two distinct labor markets in the region. See Schwanen et al. (2003) for illustrative diagrams of the types.

I calculated N1 and N2 for all MSAs for which sufficient data is available (267 of the 276 MSAs defined by the OMB in 1999¹). Before measuring N1 and N2, one additional step must be implemented. The VDL scheme relies on measuring commuting into and out of the central city. The Office of Management and Budget defines central city as the principal city within a region. Up to two additional cities can be included as central cities if they meet specific criteria (OMB, 2006). In cases where there are two or three central cities in a region, the Census Bureau bases selection of central cities primarily upon commuting data. However, the VDL scheme does not allow for measuring flows into multiple central cities within a region, leaving two reasonable alternatives: use only the principal city or aggregate all central cities into one artificial (and spatially non-contiguous) central city. I use the principal city as the definition of the central city; the option of aggregating not only combines areas that are not spatially contiguous, but also combines places that have distinguishing features, even when the places are spatially contiguous, as in the case of Champaign and Urbana, Illinois.

Figure 2.1 shows the distribution of MSAs along the measures N1 and N2. The lines are set at the median point for N1 and N2, following VDL's example. The medians of N1 and N2 are lower in Figure 2.1 than in van der Laan's Dutch data. This may result from the small sample size in the Dutch data. This might also reflect differences in U.S. and Dutch commuting patterns, or a difference in MSA/DUS (Daily Urban Systems, the Dutch equivalent of MSAs) definitions (for instance, the size of the space around a central city that is included in the region, since MSAs are built from counties and DUSs are not). The N1 median in particular is much lower

¹ N1 and N2 values cannot be calculated for Anchorage, AK; Athens, GA; Danville, VA; Enid, OK; Jonesboro, AR; Lawton, OK; Lincoln, NE; Owensboro, KY; Topeka, KS. There are no commuting flows reported between the central cities of these cities and any other place within the MSA.

using U.S. data than in the Dutch case. This indicates that U.S. cities are less traditional, relying less on the flow of suburban workers to the central city than on other, more complex spatial patterns. This finding seems consistent with the well-documented suburbanization of America.

The extreme outlier in the Decentral quadrant is Clarksville-Hopkinsville, TN-KY. The outlier in the upper right corner of the Central quadrant is Grand Junction, CO. This means that a significant share of labor market traffic in Grand Junction is directed from the suburbs to the central city. As points of reference, the New York City CMSA has an N1 of 0.26 and an N2 value of 0.36, putting it in the Cross Commuting quadrant. Chicago has an N1 value of 12.59 and an N2 of 8.46, putting it in the Decentral quadrant, but near the median point of both the N1 and N2 distributions (15.79 and 6.74, respectively).

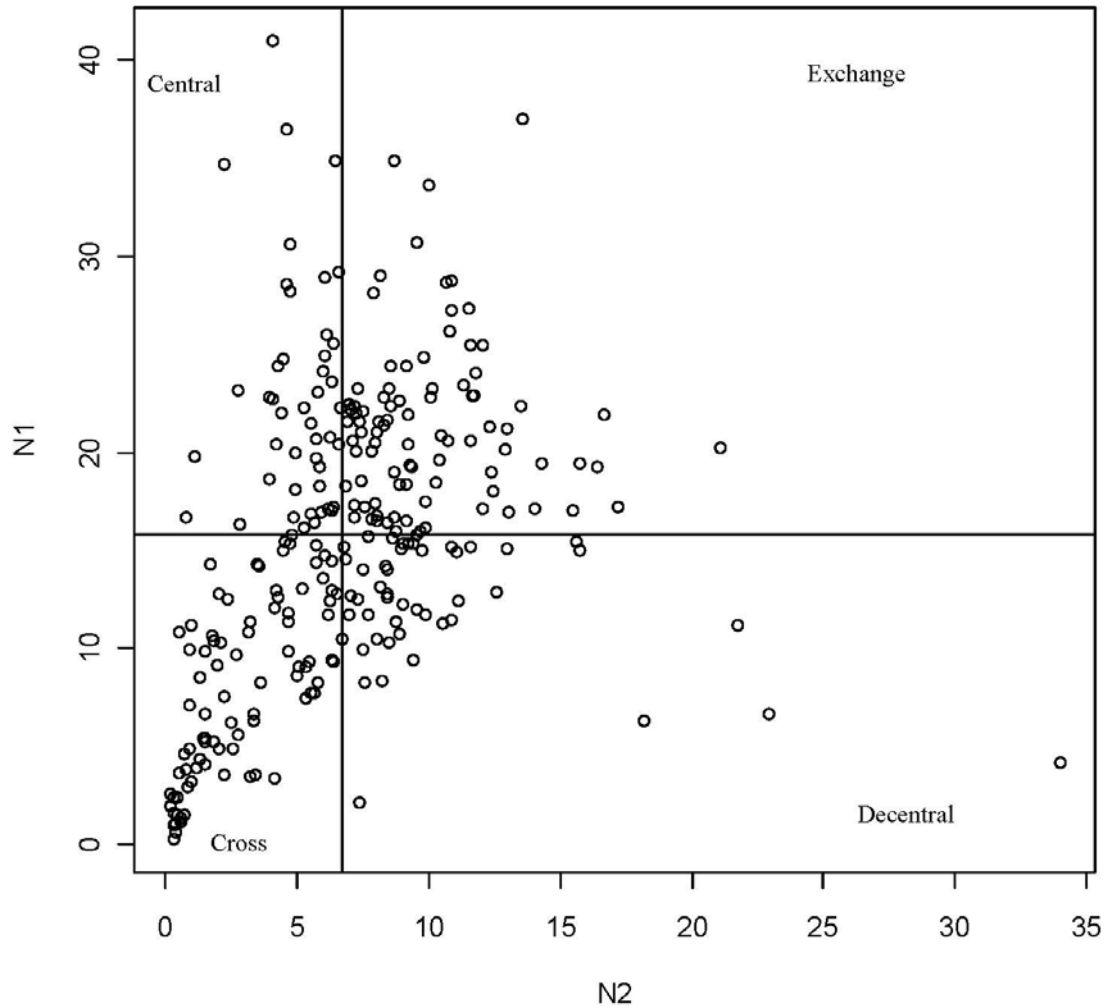


Figure 2.1: Distribution of U.S. MSAs along N1 and N2 measures

2.3 Spatial Structure and Theory

The studies on commuting time and distance provide a rich body of theory on which to ground a study of spatial structure. This section briefly reviews that literature and reviews the hypotheses that guide the model presented in the next section. Testing the relationships between existing theory and the VDL structure will help to ground the structure in the scholarly discussion on commuting as well as set up a research framework for extending its practical applications. Because the models (described in the next section) used to test this body of theory

use N1 and N2 as dependent variables, hypotheses relating to each theoretical component are expressed in terms of N1 and N2.

Theory

Spatial Structure—Accessibility and Monocentrism versus Polycentrism

Spatial accessibility generally refers to the ability of workers within a region to access employment opportunities, though definitions vary. Accessibility has been of key interest in studying, among other topics, segregation (Gottlieb and Lentnek, 2001), job search models (Eliasson et al., 2003), and transit choice (Shen, 2000). Studies repeatedly show accessibility's significance. Even given different measures and definitions, accessibility influences commuting patterns, and thus spatial structure, within regions.

Accessibility can be measured in numerous ways. Eliasson et al. (2003) measure intra-regional accessibility by counting the population of working age within a given area. Shen (2000) creates scores based on number of jobs, number of workers, automobile ownership, and impedance functions to measure accessibility for workers who are auto drivers and transit riders. Cervero and Duncan (2006) count job, retail, and service destinations within a given radius of a survey respondent's home. The methods of testing the importance of accessibility also vary, as the models and methods vary considerably across these cited papers. Regardless, accessibility remains the most consistently significant explanatory variable in studies involving spatial structure.

As Cervero and Duncan (2006) quote from Handy and Niemeier (1997), "no one best approach to measuring accessibility exists; different situations and purposes demand different approaches" (p. 478, quoting from p. 1181). I use a straightforward measure: the number of

vehicles used for commuting divided by the employed population in the region. With increasing accessibility, regions are expected to be more often multi-nodal, with less local commuting. In other words, I hypothesize a negative relationship between accessibility and N1 and a positive relationship with N2.

Gender Studies

Gender has been of interest because men both earn more and commute farther than women, seemingly irrespective of type of residential location or industry of work (see MacDonald, 1999). Two theories have emerged to explain women's commuting patterns relative to men's: the Entrapment Theory and the Household Responsibility Theory.

The Entrapment Theory focuses on women's *inability* to travel as far as men to obtain more lucrative employment. Women can be entrapped by inaccessibility of transportation (Moss et al., 2004), by paternalistic social structures (Little and Austin, 1996), by a concentration of local industries, typically in the service sector or textiles (Cristaldi, 2005), or by discriminatory wages in better-paying, farther away industries (Carlson and Persky, 1999). Van Ommeren et al. (1999) support the theory in their finding that marriage restricts the frequency with which women change jobs.

The Household Responsibility Theory (HRT) contends that women hold household and family responsibilities that keep them close to home. Theorized causal mechanisms include encouragement to work near the home community (Moss et al., 2004; Turner and Niemeier, 1997), an oppressive and paternalistic rural social structure that forces women to accept multiple responsibilities (Little and Austin, 1996), and child rearing responsibilities (McQuaid, Greig, and Adams, 2001). Others (e.g. White, 1986) find no support for the HRT. Phimister, Vera-Toscano,

and Weersink (2002), for example, see no barriers to rural women's mobility, arguing that socioeconomic standing of rural women is consistent with the observed trend toward smaller commutes.

As a measure of the role of gender in a region's spatial structure, I include labor force participation by gender. The literature on gender indicates that where the female labor force participation rate is high, the average commute time will be shorter. Since Schwanen et al. (2004) find that average commute time is shorter in monocentric cities, I anticipate finding higher female labor force participation rates in Central-type cities (i.e. a positive relationship with N1 and negative with N2). I also anticipate that the female labor force participation rate will be positively correlated with accessibility.

Industry and Occupation

The literature relating commute time and/or distance to industry and occupation is largely inconclusive. Perhaps using commute time and distance are poor metrics for testing the relationship between spatial structure and regional economics. Nevertheless, two broad theories find support across the literature. First, commuting time and efficiency (degree of cross-hauling) by occupation and industry vary (Artis et al., 2000; Gessaman and Sisler, 1976; Gober et al., 1993; Krout, 1983; Moss et al., 2004; O'Kelly and Wook, 2005).

Second, the service sector tends to draw from local workers rather than in-commuters (Artis et al., 2000; Moss et al., 2004; Krout, 1983; Turner and Neimeier, 1997). Service sector firms may have a preference for local workers (Turner and Neimeier, 1997). Another explanation is that service sector positions tend to have low barriers to entry and flexible work schedules, making the jobs attractive to women who are entrapped or who manage household

responsibilities (Moss et al., 2004). Finally, Artis et al. find empirical evidence for Simpson's claim "that labour market size increases with the worker's qualification level" (p. 1444, 2000).

Academics find less room for agreement when studying other industries and sectors. For example, Clemente and Summers (1975) found that within a manufacturing firm there is no relationship between occupation and commuting distance. More recently, Moss et al. (2004) and Artis et al. (2000) find that more educated workers tend to commute more.² However, Moss et al. find that professional workers commute shorter distances (at a non-significant level), while Artis et al. find that professional workers commute more in order to maximize use of skills and thus income. See also McQuaid et al. (2001) and Fernandez and Su (2004).

To test the relationship between socioeconomics and spatial structure, I use average compensation per job rather than economic structure variables such as percent employment in the service sector. I do this for two reasons. First, it is difficult to identify demographically-driven impacts on spatial structure from employment data in broadly-defined economic sectors. Incomes and occupations within the service sector, for instance, vary widely. Employment statistics for more narrowly defined industries suffer from non-disclosure, sometimes even for small MSAs. Second, van der Laan hypothesizes a relationship between spatial structure and a region's ability to shift to a knowledge-based economy (KBE). KBEs are not characterized by strong employment in any one industry (e.g. Vence-Deza and Gonzalez-Lopez, 2008). A KBE works through upgrading multiple industries for higher returns to investment across the local economy. Using average compensation per job measures this phenomenon better than employment in broadly-defined industries. The limitation of using average compensation is that it generally varies with city size and somewhat with region.

² "Commute more" is measured differently in these two papers—one by time and one by crossing regional borders.

Van der Laan (1998) calls Central regions monocentric, non-complex regions. Consequently, given the theory presented here, I would not expect these regions to have high levels of average compensation. Theory thus predicts a negative relationship between average compensation and N1 and a positive relationship with N2.

Urban Integration and Rural Amenities

The inclusion of rural amenities in spatial structure studies allows researchers to investigate the influence of housing affordability on regional structure in high-amenity areas (Gober et al., 1993), the potential for commuting to offset rural decline (Moss et al., 2004, see also Partridge and Rickman, 2005), the role of family in residential location preference (Clark and Withers, 1999; Davis and Nelson, 1994; Green, 1997; Mok, 2007; Rouwendal and Meijer, 2001), the mechanism driving regional restructuring (Renkow and Hoover, 2000), and the potential for rural development given expanding metropolitan labor markets (Berry, 1970; Hazans, 2004).

Rural amenities can be widely construed as the characteristics of a bucolic setting which entice individuals or households to visit or settle permanently. Each MSA receives a score from 0-100 for rural amenities, which indicates the percentage of places within the MSA which are rural. Places are categorized as rural using RUCA codes (ERS, 2005) and GIS. Using GIS, I first locate the Census tract of each place's centroid. Places within tracts of RUCA codes 4-10 are counted as "rural" places. I also control for housing affordability to better understand the role of rural amenities versus income-housing matching. The literature does not set up a clear hypothesis for the relationship between rural amenities and N1 and N2, or the VDL types. It seems likely that rural amenity-rich regions would be Central (higher N1, lower N2), since small towns are,

theoretically, embraced for home-life qualities, not economic purposes; they are bedroom communities. In short, places with high levels of rural amenities are not expected to have local employment structures.

Dual-Income Households

Commutes vary between single workers and workers in two-wage-earner households. Consequently, spatial structure is expected to vary with household type. The most studied factor in dual-income commuting is housing preference for households with and without children (Clark and Withers, 1999; Davis and Nelson, 1994; Green, 1997; Mok, 2007; Rouwendal and Meijer, 2001). Households with children prefer larger housing in smaller towns, which has specific implications for spatial structure, though I do not control for the presence of children in this paper. I measure the impact of dual-income household status by including labor force participation by marital status. Like rural amenities, the hypothesis stemming from this literature is unclear, but it seems reasonable to anticipate a positive relationship between the percent of dual-income households and N1, and a negative relationship with N2.

The dual-income household literature also relates to and enriches the gender-based literature. For a discussion, see Clark and Withers (1999), Green (1997), Mok (2007), Plaut (2006), Rouwendal and Meijer (2001), Skaburskis (1997), and van Ommeren (1999).

2.4 The Model

I use ordinary least squares regression to test the theoretical relationships described in the previous section. The dependent variables are N1 and N2. I use N1 and N2 rather than VDL

spatial structure type as dependent variables because the cut-off points between VDL types are set by the median of N1 and N2, which is somewhat arbitrary and may bias the results.

In addition to the variables drawn from theory, I also control for location using the Census Bureau's designations for Division (see Appendix, Figure A1). Division was assigned according to the location of each MSA's principal city. Controlling for Census division helps to control for some of the historic reasons that cities developed differently. For instance, cities like Philadelphia and Annapolis developed before the automobile, with dense and narrow streets, while Los Angeles took form with the explosion of the automotive industry in the United States. Variables, definitions, and data sources are provided in Table 2.2. All data and conclusions are drawn at the MSA-level. The right hand side variables are drawn from the 2000 Census and other data sources from 2000.

I calculated an interaction term for all combinations of dummy and scale variables. The interaction terms did not strengthen the models and were consequently dropped. Many of the variables listed in Table 2.2 were highly correlated. To reduce multicollinearity in the model without restricting it to a very small number of variables, I used a principal component analysis to reduce the explanatory variables into three components. Table 2.3 shows the loadings of each variable on its most representative component. This is provided to guide interpretation of model results. The resulting OLS models of N1 and N2 show neither multicollinearity nor heteroskedasticity.

Table 2.2: Variables and Definitions

Variable	Definition	Data source
Non-white	% of the population that is not white alone	Census 2000
Elderly	% of the population that is age 65+	Census 2000
Foreign	% of the population that is foreign born	Census 2000
Education	% of the population ages 25+ with at least a bachelors degree	Census 2000
Unemployment	% of the population ages 16+ that is in the labor force but unemployed	Census 2000
Population	Total population	Census 2000
Income	Per capita personal income	Bureau of Economic Analysis, REIS Tables, 2000
Labor force participation	% of the population ages 16+ that is in the labor force	Census 2000
Affordability	% of households with owner costs less than 35% of household income	Census 2000
Rural	% of the population that is classified as rural	Census 2000
Access	% of the employed population that uses public transportation to get to work	Census 2000

Table 2.3: Component loadings

Variable	Component 1: Context	Component 2: Econ	Component 3: Demog
Foreign	-0.378		
Population	-0.408		
Afford	0.335		
Rural	0.374		
Access	-0.421		
Education		-0.384	
Unemployment		0.464	
Income		-0.364	
Labor force participation		-0.470	
Non-white			-0.306
Elderly			0.699

2.5 Results and Discussion

Results (Table 2.4) provide partial support for the VDL conceptual model. The nodality-based model predicted monocentric regions, but does not reliably predict regions that appear polycentric given our hypotheses about polycentric regions, suggesting incomplete theoretical understanding of the drivers of polycentricity or invalid measurement.

Table 2.4 generally indicates that VDL monocentric regions resemble literature-based theoretical monocentricity; they have older populations, smaller populations, more affordable housing, less accessibility to public transportation, and smaller shares of foreign-born residents. In short, the CONTEXT and DEMOG variables predict VDL monocentricity as hypothesized. The relationship between N1 and city size is especially interesting, as it supports the theory that as cities grow they become more complex (see Clark and Kuijpers-Linde, 1994). Spatial structure is a reflection of the stage of MSA evolution.

On the other hand, the hypotheses drawn from literature regarding the demographics, economy, and context of polycentric regions are not reflected by regions VDL classifies as polycentric (having a higher N2 score). The N2 model as a whole is not statistically significant. This does not mean that these regions are not polycentric, but it does mean that our theoretical understanding of polycentricity does not align with an empirical measurement of polycentricity.

Table 2.4: Regression analyses of N1 and N2

	N1			N2		
	Estimate	Std. Error	Signif.	Estimate	Std. Error	Signif.
Intercept	14.8794	2.2805	***	8.90744	1.32703	***
CONTEXT	0.8152	0.2802	***	0.22147	0.16303	
ECON	-0.4227	0.3691		0.02635	0.2148	
DEMOG	0.9738	0.3919	**	-0.45683	0.22802	**
ESC	2.3641	2.8476		-1.78544	1.65705	
PCF	3.7797	2.9378		-1.51954	1.70954	
MNT	-0.1121	2.7702		-2.86045	1.61204	*
WSC	-0.7855	2.7111		-2.97319	1.57763	*
SA	2.929	2.4982		-2.75142	1.45374	*
ENC	-0.9402	2.5557		-0.86307	1.48722	
MA	0.9751	2.7651		-0.16242	1.60907	
WNC	-2.1618	2.7848		-2.86298	1.6205	*
Adj. R ²	0.0699			0.02657		
F-statistic	2.817			1.66		
P-value	0.00173			0.08286		

* indicates significance at the 0.10 level, ** indicates significance at the 0.05 level, *** indicates significance at the 0.01 level

The bulk of spatial structure research revolves around topics relating to regional economics. It is therefore most surprising that the economic variables are not statistically significant in the N1 and N2 models. This suggests that further study, in which one or a few regions are studied in a time series model, might be an appropriate approach. It seems likely that a region's economy and its spatial structure do not develop in perfect tandem. However, without clear empirical evidence as to which comes first, and at what time lag, constructing a better specified model will remain difficult.

Surprisingly, the Census Division variables (with New England as the comparison category) did not strengthen the N1 model, but some are statistically significant in the N2 model. With New England as the reference Division, all other Divisions carry a negative coefficient for

the N2 model, indicating that reverse commuting (central city to suburb) is more common in New England than elsewhere.

Taken together, the results of N1 and N2 indicate that the VDL approach adequately measures traditional commuting in a way that is validated by its relationships with explanatory variables. In other words, the N1 model is significant (though with a very low R-squared value) and aligns reasonably well with theory. However, the N2 model is not significant at the 0.05 level. This indicates that the VDL conceptual measurement either does not reliably detect polycentricity, or our theoretical understanding of its drivers is incomplete by a wide margin.

2.6 Conclusion

This paper set out to assess the applicability of a nodality-based spatial structure scheme to U.S. regions. In sum, the VDL scheme can be measured and applied for U.S. regions. Models of the VDL spatial structure variables N1 and N2 indicate that the N1 variable, which describes the traditional suburb-to-central city commuting pattern, is supported fairly well by theory. However, N2, which would theoretically permit the detection of polycentric regions, finds less support from theory.

This work suggests that while the straightforward concept of the traditional, monocentric city can be readily related to contextual, economic and demographic variables, our understanding of multinodality is less complete. Much work remains to be done in investigating the causal mechanisms of multinodality and its temporal relationships with economic and demographic changes. Based on the work of Clark and Kuijpers-Linde and this manuscript, it would seem that a productive avenue may be the development of more detailed conceptual diagrams of multinodal cities, from which case studies of cities can be carried out.

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Chapter 3: Spread and Backwash Effects for Non-metropolitan Communities in the U.S.

3.1 Introduction

The rural idyll provides an image of a self-sustaining, economically viable countryside dotted with close-knit, picturesque communities. Like all ideals, however, the image is flawed. “The wellbeing of people in the countryside is closely inter-linked with that of their urban cousins, whether an asset or a liability” (Partridge, Bollman, Olfert, and Alasia, 2007, p. 128). For those studying rural and regional development then, urban-rural linkage models can provide critical information about the pathways by which cities both help and hinder communities.

As Partridge et al. (2007) point out, the concept of urban-rural linkages is not a new one. Current interest stems from ongoing developments in the literature, especially within the subject areas of new economic geography, deconcentration and restructuring, rural amenities, demographic effects on regional spatial structure, and urban sprawl. For rural and regional development, information about the economic relationship between communities and urban centers can provide meaningful information for transportation development projects. Highway development is a success story of the Appalachian Regional Commission’s work. Research relating urban growth and rural and regional development can only make those projects more fiscally efficient.

The notion that rural and regional development is tied, both positively and negatively, to urban development is commonly referred to as spread-backwash effects. In short, this paper tests three methods of measuring spread and backwash effects of 276 Metropolitan Statistical Areas/Consolidated Metropolitan Statistical Areas (collectively henceforth referred to as MSAs) on population growth in 2,170 non-metropolitan Census places across the U.S. from 2000-2007.

Traditionally, spread-backwash effects are measured as a function of income growth, population growth and the distance between the non-metropolitan place and the nearest city. This paper challenges the notion that only the nearest city matters, suggesting that instead, non-metropolitan places' growth can be influenced by multiple cities. To test that hypothesis, I measure population growth via three separate conceptual approaches, as a function of the characteristics of: the nearest city, multiple cities weighted by their inverse-distance to the non-metropolitan place, and multiple cities weighted by the commuting flow from each non-metropolitan place to the MSA. Though theory suggests that an inverse-distance weighting of multiple cities is preferable, the strength of the nearest city model indicates that non-metropolitan economies evolve to serve proximate demand. A more elaborate specification of the inverse-distance model is suggested.

3.2 Background on Spread-Backwash Concept

The spread-backwash concept began in the 1950s with the nearly simultaneous publications of Hirschman (1959) and Myrdal (1957). Hirschman's "trickling down" effects are conceptually analogous to Myrdal's spread effects—those effects of urban influence which benefit the outlying areas. According to Hirschman, the most important of these effects is the purchase and investments of the affluent region in the outlying region. The negative (backwash or polarization) effects include migration to the more developed region, especially of the more skilled and trained workers, and weak production in the outlying region, caused by superior competition in the more developed area. Hirschman acknowledges in a footnote that Myrdal published his spread-backwash ideas first, though he criticizes Myrdal's emphasis on cumulative causation, which Hirschman believes implies too dismal an ending for the outlying areas (Hirschman, 1959, p. 187).

At its simplest, spread and backwash can be measured by either population change or income change as a function of distance to the nearest city and growth in that city. Regardless of a town's economic structure or amenities, it is possible for the community to grow if its workers have access to the city when there is excess labor at home, or to access the urban service and recreation sectors. As Partridge et al. (2007) describe in detail, the concept of population growth effects that are attributable to distance only can be referred to as the urban distance discount (UDD). In addition to the UDD, several factors may influence spread and backwash effects, most notably, the income growth rate and population growth rate of the nearest city (or set of cities which influences each non-metropolitan place), and the characteristics of the non-metropolitan community itself.

The transition of these ideas from theory to models began in earnest in the late 1980s when Carlino and Mills (1987) explored determinants of growth at the county level. Intra-metropolitan growth was taken up by Boarnet's (1994) econometric model of spread-backwash effects introducing the spatial lag of population and employment change. Over time the model has been extended, most notably by Henry, Barkley, and Boa (1997), who find that spread effects are greater when outlying places are near a decentralized urban node; Henry, Schmitt, Kristensen, Barkley, and Bao (1999), who find that spread effects depend on size of local labor zones near the outlying area; and Rey and Boarnet (1998). This work is tied closely to studies of agglomeration and spillovers and to questions of industrial location and production. Gaile (1980) reviews the concepts related to spread-backwash effects and the theoretical and empirical approaches taken for its study.

The early papers on spread-backwash effects limited their focus to small regions, such as communities within South Carolina (Henry, Barkley, and Bao, 1997), or parts of France (Henry,

Schmitt, and Piguie, 2001). The first, and to the author's knowledge only, study to incorporate a larger study area is Partridge et al. (2007), which considers spread and backwash effects in Canada from 1981-2001. Most papers also rely on ordinal measurements of rural proximity, rather than using continuous variables such as distance. See Partridge et al. (2007, p. 129-130) for a fuller discussion of this advancement.

The following are two of many approaches to studying rural and regional development to which the spread-backwash framework can apply. First, Moss, Jack, and Wallace (2004) begin their work with the notion that when rural economies face structural economic changes, workers can sustain their communities via commuting to proximate urban labor markets. This is a special case of spread effects of urban growth. Though the non-metropolitan place's population may not grow, if communities are sustained then population sizes also will not decrease at the rate that would be observed if commuting were not possible. Second, Berry (1970) describes the gradient of income change with increasing distance from an urban center given different parameters. He hypothesizes that rural areas fare better when they have access to multiple metropolitan labor markets and when the cities to which they have access are larger. His hypotheses, like Moss et al. (2004) rely on the spread effects of urban areas. Furthermore, he provides some hypotheses of the traits of the urban centers that will influence the degree of the spread-backwash effects.

U.S. Context and Sample

Given basic descriptive statistics about U.S. non-metropolitan places, it is likely that non-metropolitan residents can commute to proximate urban labor markets and perhaps often have access to multiple cities. The vast majority of non-metropolitan places are relatively close to an MSA. Fifty-nine percent of the communities studied in this paper (sample size is 2,170 non-

metropolitan places, defined below) are within fifty miles of the primary central city of an MSA, and 13 percent are within 25 miles. This contradicts the image of a non-metropolitan American that is truly isolated (though there are 155 places that are more than 100 miles from a central city). Despite the proximity, these places are in non-metropolitan counties, meaning that there is not a strong commuting tie to the metropolitan central county of the MSA. Both Moss et al. (2004) and Berry (1970) present notions of non-metropolitan residents that may still be accurate; there is room for increased commuting to cities, pushed by either excess labor supply or by structural change.

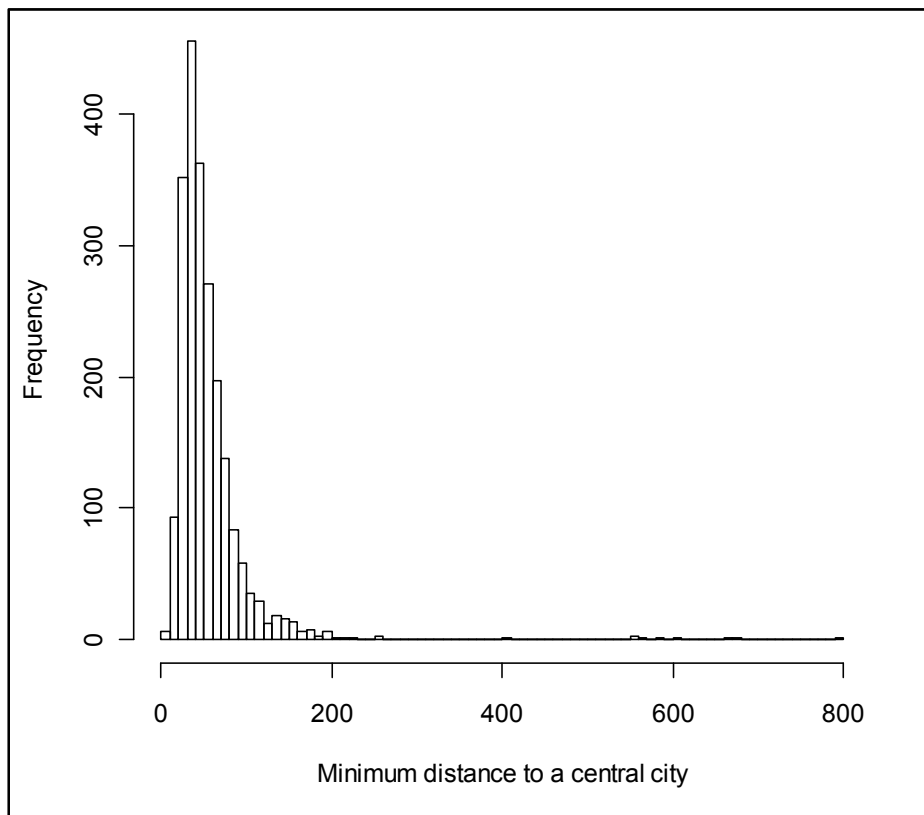


Figure 3.1: Distribution of distance (miles) between communities and nearest MSA

This paper builds on the spread-backwash literature in three ways. Primarily, I test the hypothesis that non-metropolitan places are influenced by multiple cities by comparing the

results of models constructed with three different conceptual measurements. Theoretical arguments can be made for any of the three conceptual measurements: nearest city, inverse-distance, and commuting-weighted. The nearest city approach follows the traditional view of the city; atomistic and monocentric. Discussions of more complex spatial structures are much newer than the concepts of spread and backwash.

Allowing cities to influence non-metropolitan growth in proportion to the inverse distance between each city and non-metropolitan place has the great strength of allowing multiple cities to influence a non-metropolitan place. It also acknowledges that goods can be brought to market in a city even when the non-metropolitan residents do not commute to the given city; consider grain shipments through the Midwest, for example. This approach captures spread and backwash effects that affect both commuters and businesses, but does not include any weighting for variation in infrastructure provision which enables both commuting and freight movement. In this paper I introduce a proxy for infrastructure provision. The primary weakness of this approach is that it likely permits influence from too wide a sample of cities.

The third approach, commuting-weighted, also has the strength of permitting influence from multiple cities. Unlike the inverse distance approach, using commuting flows allows the selection of the unique set of cities that is likely to influence growth in a given non-metropolitan place *via commuting*. The weakness of this approach is that it ignores the ability to ship goods to markets situated beyond the commuting sphere, thus underestimating spread effects from investment in manufacturing, which is a key theoretical spread effect. This approach likely underestimates the set of cities that influence non-metropolitan growth. It could be argued that cities within a pre-selected distance band could be permitted to influence non-metropolitan place-level growth in a model. However, that approach would over-estimate for some and under-

estimate for other non-metropolitan places the appropriate set of influential MSAs, which is not an improvement over the methods selected.

The second principal contribution is that I undertake a study of MSAs across the U.S. (see Figure 3.2), where studies have generally been limited to urban areas within small regions. The sample includes 276 MSAs and 2,170 non-metropolitan places. Finally, the empirical specification controls for characteristics of both the cities and the non-metropolitan places. Communities may be attractive to households because they are bedroom communities to cities, or because they provide access to attractive non-employment related features of the city. Consequently, it is appropriate to control for both sets of characteristics.

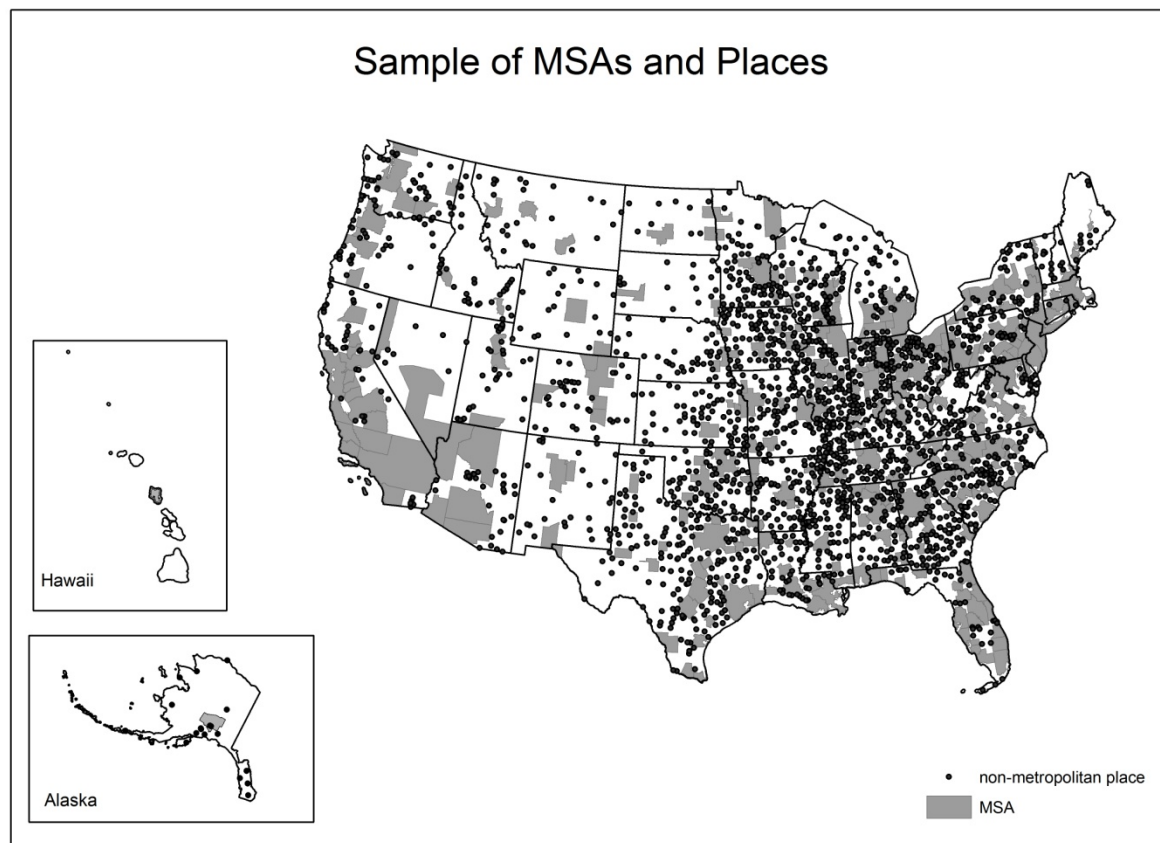


Figure 3.2: Sample of MSAs and non-metropolitan places used in study

3.3 Empirical Specification and Data

Conceptually, the model construction follows the literature (Partridge et al. 2007; Greene 1997; Partridge and Rickman 2003; Rappaport 2004a, 2004b). These papers develop and build on a partial adjustment model. This model assumes a steady-state population density that represents the well-being of the average household and is a function of the amenities and economy (utility and productivity) of the local community. Population density in year t is assumed to be a weighted average of year 0 actual population and the equilibrium population density. Here, λ is assumed to be the speed of adjustment for mobility costs.

$$PD_{it} - PD_{i0} = \lambda\beta_{i0} - \lambda PD_{i0}, (0 \leq \lambda \leq 1) \quad (1)$$

The left hand side can be approximated by percentage change in population, as the land area, which would make the left hand side a density calculation, is differenced away. For a fuller discussion of the appropriateness of using partial adjustment models, see Partridge et al. (2007). Spread and backwash effects are usually measured by either population or income change in non-metropolitan places (or other levels of geography). Based on the theoretical perspective presented by Moss et al. (2004) and Berry (1970), I chose to use population growth as the dependent variable. This is related to but clearly distinct from urban sprawl, which pushes increasing population densities outward from the urban center. Spread and backwash effects are measured using population change in communities between 2000 and 2007. This time period was selected to reduce the changing MSA and community definitions and geographic identifiers over time, and thus increase the sample size.

The right hand side includes distance to the nearest MSA, the spread-effect-generating changes in MSA population growth and income growth, plus control variables (for both the MSAs and the non-metropolitan places) and regional dummy variables. The right hand side

variables, as a result of this theoretical setup, are initial year measures, and are assumed to affect household utility and firm productivity over time in the location.

The specification of the full models follows from the reduced form partial adjustment model given in (1) and the three approaches to conceptual measurement: using the nearest city only, weighting cities by inverse-distance, and weighting cities by commuting flow from non-metropolitan place to MSA. The full specification for each conceptual measurement includes three groups of variables, Spatial, Control, and Division.

The SPATIAL variables include the key spread-backwash variables. Spread-backwash theory revolves primarily around the growth benefits of urban proximity, urban income growth, and urban population growth. Therefore, the SPATIAL variable set includes distance to the nearest MSA, income growth (average annual pay) in the MSA, and population growth in the nearest MSA. Each of those variables is also interacted with distance to the nearest MSA. Starting year level values for population and income were also included to account for effects of the urban hierarchy; larger cities likely have spread effects over longer distances than small cities (Ali, Olfert, and Partridge, 2010). Additionally, the squared terms for initial year population and distance to the nearest MSA are included to detect nonlinearities. Summary statistics for the non-interacted key SPATIAL variables are given in Table 3.1. This table indicates that the commuting weighted model reflects non-metropolitan places' access to much larger and faster growing cities than do the other two models. The difference in population size is the result of a very few large observations; the median is approximately one million.

Table 3.1 Summary statistics for key spread-backwash variables

	Nearest city		Inverse-distance		Commuting weighted	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Place-level population, 2000	8,417	7,756	8,417	7,756	8,417	7,756
Place-level % change in population	1.39%	11.12%	1.39%	11.12%	1.39%	11.12%
Distance to nearest central city (miles)	54.59	46.97	54.59	46.97	54.59	46.97
Nearest MSA population, 2000	475,221	820,132	742,834	102,073	1,650,455	2,144,579
Nearest MSA % population change	7.00%	6.95%	6.63%	1.54%	8.06%	5.99%
Nearest MSA income, 2000	\$26,092	\$3,702	\$26,481	\$540	\$28,116	\$5,354
Nearest MSA income change	29.82%	8.44%	29.92%	1.78%	28.62%	8.00%
Nearest MSA industry mix component	0.099	0.018	0.098	0.004	0.098	0.019

The CONTROL variables account for the industry mix effect, economic and demographic characteristics, and recreation amenities of MSAs, as well as demographic and economic conditions in the observed non-metropolitan communities. The industry mix effect is included to capture the likelihood of employment demand changes over the period in the MSAs, since labor demand is central to the decision to commute rather than migration from the non-metropolitan community. To reduce multicollinearity, these variables were put into a principal components analysis. The factor scores for components with an eigenvalue of at least 1.00 were used in the analysis. A complete listing of the MSA and place-level control variables is given in the Appendix (Table A1).

Finally, dummy variables for Census Division were included. This was done to control for the Rustbelt-Sunbelt migration patterns in the U.S., thereby controlling for climate and lifestyle-based amenity considerations and regional economic and housing market conditions which the model otherwise cannot distinguish. This also helps to control for variation in county

size across the U.S.; counties in the American West are much larger than those east of the Mississippi River. Consequently, it is likely that some Western non-metropolitan places are farther from central cities than are eastern non-metropolitan places. This effect should be captured by the inclusion of the DIVISION term.

In general, the models are specified as given below, (equation 2).

$$G_{i(t-0)} = \alpha + \theta POPDEN_{i0} + \psi SPATIAL_{i0} + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \gamma DIVISION_{i0} + \varepsilon_{i(t-0)} \quad (2)$$

Where G_i = percent population change in community i .

$X_{1...4}$ terms represent the components (constructed from the CONTROL variables) defined in the principal components analysis. The number of components varies between the three sets of models; the nearest city models have seven components, the inverse-distance models have five, and the commuting weighted models have four. The specification in (3) illustrates the functional form in generalities.

For the first conceptual measurement, in which only the characteristics of the nearest MSA are considered, the specification in (2) is straightforward. In the second (inverse-distance weighted) and third (commuting-weighted) models, the specification is markedly different and novel.

In the second and third models, the SPATIAL variables that describe the nearest MSA (population change in the nearest MSA, income change in the nearest MSA, etc.) are constructed by multiplying row-standardized weights matrices by a matrix of the MSA-level SPATIAL variables. In the case of the inverse-distance weighted approach, a row-standardized weights matrix of the inverse distance between each non-metropolitan place and MSA is used. This is constructed by taking the matrix of inverse distance between each non-metropolitan place and

each MSA (where non-metropolitan places are on the x-axis and MSAs are on the y-axis), summing each row, then dividing each cell in the row by the row's total, such that the inverse distances between each non-metropolitan place and each MSA sums to one for each non-metropolitan place. This row-standardized matrix is then multiplied against the explanatory variables. In the case of the commuting-weighted model, a row-standardized matrix of the normalized commute flow between non-metropolitan place and MSA is used.

Conceptually, row standardizing means that all non-metropolitan places have equal (distance-based) access to cities and equal (full) commuting access to cities. Using these weights results in a constructed composite city, where proximate/commuting-linked cities are given weight according to their proximity or strength of commuting tie. The row-standardized weights were also used to create a composite "nearest" city for the MSA-level control variables. The row-standardized weights are also used to calculate the MSA-level CONTROL variables for each observation.

The distance-interacted SPATIAL terms are constructed similarly, except that the weights matrices are not row-standardized. This allows non-metropolitan places with stronger commuting relationships or closer distances to cities to have a larger urban influence than places with weaker ties. Rather than using distance to the nearest MSA, these models approximate the interaction of distance to the composite city with the SPATIAL variables.

In sum, nine models are presented in the results. For each of the three approaches (nearest city, inverse-distance, and commuting weighted), the full model was arrived at in three stages, the first including only SPATIAL variables, the second adding the CONTROL variables, and the third adding the DIVISION variables. All nine models shown initially had heteroskedastic errors,

which I addressed using a White correction. The final specification is followed by a description of each term and its variables.

Population change was also measured for 2000-2006 (in addition to 2000-2007) to test the robustness of the model and its sensitivity over time. The right hand side variables use 2000 data, as described. The sample size is 276 MSAs and 2,170 non-metropolitan communities (incorporated Census places³). Non-metropolitan communities include those places that are not in central or outlying metropolitan counties using the 1999 Office of Management and Budget (OMB) definition for MSAs. The sample is restricted to Census Designated Places that are incorporated or are minor civil divisions in selected states. Many of the MSAs changed boundaries between 2000 and 2007. Places that were non-metropolitan in 2000 and metropolitan in 2007 were not excluded from the sample. Excluding these places would prevent the observation of the places that are gaining dramatic spread effects via commuting. A comprehensive list of the variables with data sources is provided in the Appendix (Table A1).

3.4 Results and Discussion

The results for the period 2000-2007 are shown below in Tables 3.2-3.4. These results are strongly similar to the results for population change from 2000-2006, which was included as a test of robustness of the model. The CONTROL variables are omitted from this presentation due to space constraints. They are generally statistically significant with the anticipated signs.

Significance symbols are standard: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. The full names for the abbreviated regions are given in the Appendix (Figure A1).

³ Roughly 400 Census Designated Places had to be removed from the sample because population estimates for 2007 were not available. The Census Bureau provides population estimates for all incorporated places and minor civil divisions in selected states; not all Census Designated Places are incorporated.

Table 3.2: Nearest city models

	SPATIAL			SPATIAL + CONTROL			FULL		
	coeff.	White s.e.	Sig.	coeff.	White s.e.	Sig.	coeff.	White s.e.	Sig.
Intercept	1.19E+01	4.3713	***	2.77E+01	4.9652	***	1.73E+01	4.8733	***
Log of population density	-1.81E+00	0.4360	***	-3.43E+00	0.5069	***	-2.97E+00	0.5410	***
Dist to nearest central city	-5.63E-02	0.0526		-4.43E-02	0.0558	**	-2.13E-02	0.0534	*
Square of dist to the nearest central city	-6.68E-05	0.0000	**	-6.66E-05	0.0000	***	-4.96E-05	0.0000	***
Access Total *	2.30E+01	7.1261	***	2.24E+01	6.9304	***	2.38E+01	6.9052	***
% pop change in the nearest MSA	4.04E-01	0.0710	***	2.91E-01	0.0744	***	2.06E-01	0.0718	***
Dist x % pop change in the nearest MSA	3.21E-04	0.0013		-5.37E-04	0.0013	*	-6.71E-04	0.0012	*
% inc change in the nearest MSA	-1.97E-02	0.0459		-8.50E-03	0.0442	**	2.67E-02	0.0459	*
Distance x % inc change in the nearest MSA	1.78E-03	0.0007	**	8.00E-04	0.0007	**	1.58E-04	0.0007	**
Pop, 2000, in the nearest MSA	-1.79E-03	0.0013		-1.30E-03	0.0013	**	-1.19E-03	0.0013	*
Dist x pop in the nearest MSA	5.26E-05	0.0000	**	3.21E-05	0.0000	**	3.50E-05	0.0000	*
Inc in the nearest MSA	-8.25E-02	0.1240		-1.92E-01	0.1428	*	-1.76E-01	0.1369	*
Dist x inc in the nearest MSA	7.64E-05	0.0014		5.61E-04	0.0016	**	1.71E-04	0.0015	**
ESC							7.59E+00	1.4344	***
PCF							1.09E+01	1.7121	***
MNT							1.11E+01	1.5762	***
WSC							5.60E+00	1.1887	***
SA							8.98E+00	1.3033	***
ENC							4.07E+00	1.1265	***
MA							3.65E+00	1.3015	***
WNC							3.54E+00	1.1266	***
Adjusted R ²	0.1424			0.2383			0.272		

Table 3.3: Inverse-distance weighted models

	SPATIAL			SPATIAL + CONTROL			FULL		
	coeff.	White s.e.	Sig.	coeff.	White s.e.	Sig.	coeff.	White s.e.	Sig.
Intercept	-2.92E+01	31.2693		6.91E+01	41.4506	*	5.62E+01	40.5919	
Log of popdensity	-2.78E+00	0.5344	***	-3.61E+00	0.6037	***	-3.21E+00	0.6039	***
Dist to the nearest central city	-3.30E-02	0.0133	**	-2.23E-02	0.0121	*	-3.43E-02	0.0126	***
Square of dist to the nearest central city	7.80E-06	0.0000		-6.80E-06	0.0000		5.76E-06	0.0000	
% pop change in the composite nearest city	5.51E+00	0.8742	***	4.10E+00	0.9896	***	1.44E+00	1.3103	
Distance x % pop change in nearest city	-5.12E+00	1.6867	***	-2.79E+00	1.6610	*	6.50E-01	2.4169	
% inc change in nearest composite city	-9.39E-01	0.7384		-9.81E-01	0.7136		2.17E-01	1.0749	
Dist x % inc change in nearest city	1.27E+00	1.2539		2.41E+00	1.2670	*	1.10E+00	1.7479	
Pop, 2000, in composite nearest city	7.27E-03	0.0170		1.43E-02	0.0223		2.22E-02	0.0226	
Dist x pop in nearest city	2.13E-02	0.0308		2.48E-02	0.0360		2.00E-02	0.0380	
Inc in composite nearest city	1.33E+00	1.2483		-2.38E+00	1.9469		-3.12E+00	1.9510	
Dist x inc in nearest city	-5.68E-01	1.6373		-1.72E+00	1.6316		-1.14E+00	1.8892	
ESC							1.08E+01	2.2688	***
PCF							1.16E+01	3.0271	***
MNT							1.18E+01	2.5679	***
WSC							7.85E+00	2.0785	***
SA							1.12E+01	2.0144	***
ENC							8.13E+00	1.8862	***
MA							5.41E+00	1.9483	***
WNC							6.66E+00	2.0687	***
Adjusted R ²	0.1582			0.2327			0.2486		

Table 3.4: Commuting weighted models

	SPATIAL			SPATIAL + CONTROL			FULL		
	coeff.	White s.e.	Sig.	coeff.	White s.e.	Sig.	coeff.	White s.e.	Sig.
Intercept	4.12E+00	3.0467		1.72E+01	4.6744	***	1.01E+01	4.5396	**
Log of pop density	-1.64E+00	0.4164	***	-2.82E+00	0.4853	***	-2.57E+00	0.5266	***
Dist to the nearest central city	2.89E-02	0.0153	*	4.12E-03	0.0145		-3.74E-03	0.0149	
Square of dist to the nearest central city	-6.45E-05	0.0000	***	-5.48E-05	0.0000	**	-5.19E-05	0.0000	**
% pop change in the composite nearest city	4.39E-01	0.0946	***	3.93E-01	0.0873	***	2.13E-01	0.0863	**
Dist x pop change in nearest city	6.04E-01	0.9297		7.22E-01	0.8956		1.01E+00	0.8883	
% inc change in nearest composite city	5.38E-02	0.0447		9.98E-02	0.0498	**	6.73E-02	0.0552	
Dist x % inc change in nearest city	1.03E-01	0.3380		2.08E-01	0.3135		4.21E-01	0.3109	
Pop, 2000, in composite nearest city	6.21E-04	0.0002	***	4.67E-04	0.0002	**	3.93E-04	0.0002	*
Dist x pop in nearest city	-1.20E-03	0.0017		-4.54E-04	0.0017		1.36E-03	0.0017	
Inc in composite nearest city	-1.94E-02	0.0611		-1.58E-01	0.1226		-8.71E-02	0.1192	
Dist x inc in nearest city	6.89E-01	0.4089	*	4.12E-01	0.3875		8.65E-02	0.3837	
ESC							7.36E+00	1.3458	***
PCF							1.23E+01	1.5334	***
MNT							1.15E+01	1.5191	***
WSC							4.72E+00	1.1512	***
SA							8.13E+00	1.2085	***
ENC							3.77E+00	1.0296	***
MA							2.78E+00	1.2653	**
WNC							3.23E+00	1.0403	***
Adjusted R ²	0.1462			0.2239			0.2769		

Tables 3.2-3.4 provide complex results. I will discuss results in order from most general observations to specific comparisons between sets of models.

An evaluation of each table quickly indicates that the commuting-based model fails the preliminary test of external reliability; the sign on distance is positive. The rejection of this model clearly indicates that market effects are more important in producing spread effects than is commuting alone. On this point, the term “Access Total” in the nearest city model is simply the percent of each non-metropolitan place’s commuters that work in MSAs. The consistent statistical significance of this term indicates that commuting access is a critical element in delivering spread effects. However, considering a place’s exposure to a city only through the lens of its commuters produces unreliable results for the measurement of spread and backwash effects.

In comparing the remaining two sets of models, the nearest city models and the inverse-distance models, the nearest city models appear stronger. Variable signs are consistent from model to model, the adjusted R-squared terms are higher, and the variables are generally statistically significant. That the nearest city model is stronger indicates that while it remains likely that non-metropolitan places experience spread and backwash effects from multiple MSAs, a more selective weighting scheme might be appropriate. Such a weighting scheme might rely on a combination of commuting and freight shipments from places to MSAs. Going back to the example of grain shipments through the Midwest, farmers in Southern Illinois do not ship grain equally to every city within a three hundred mile radius, but rather focus shipments to places where brokers work. Data indicating production volumes for goods in places and purchase volumes for goods in MSAs could drastically enhance the measurement of spread-backwash effects.

I will focus now on more specific statistics in Table 3.2, the nearest city model. The pure distance effect, or UDD, itself is interesting. It is clear that urban proximity produces spread

effects for non-metropolitan places. After taking into account the terms for distance to the nearest city and its square, as well as the interaction terms (distance * x), I calculated that only at 405 miles from a central city does the growth benefit of urban proximity diminish to zero. This means that all but about half a dozen places in the sample benefit from urban proximity. This finding is consistent with regional science theory; within the United States (or any country), no local economy is truly closed. The assumption of a closed economy is a simplification. With an open economy, no observable place is truly outside the realm of urban spread and backwash effects.

Larger populations in nearby MSAs also produce spread effects for non-metropolitan places, theoretically by acting through congestion to discourage in-migration or by driving a spatial widening of economic activity for the region. The full model in Table 3.2 reinforces not only that larger populations produce spread effects, but that higher incomes attract people away from outlying areas and into the city, producing backwash effects. These conflicting spread and backwash effects were anticipated based on the existing literature. I had also hypothesized that population growth and income growth would have similar effects; population growth in the city would deter migration out of non-metropolitan places, while income growth would produce backwash effects for non-metropolitan places. Table 3.2 shows the spread effect of population growth on non-metropolitan places and shows backwash effects of income growth on only the first two models. The signs on the interaction terms (distance * income, distance * income change, distance * population, distance * population change) are also significant but do not show the anticipated conflicting signs (positive for population and population growth, negative for income and income growth).

The place-level and MSA-level controls are not reported because they are generally statistically significant and with the expected sign. I have chosen, however, to report the Census Division dummy variables in Tables 3.2-3.4 because the results are more interesting. The Census Division variables are all consistently both positive and statistically significant in all nine models presented (New England is the reference category). In the nearest city model, the coefficients vary from 3.54 in the West North Central region to 11.08 in the Mountain Region. This partially captures the Frost Belt-Sun Belt migration patterns in the U.S.

3.5 Conclusion

This paper sought to quantify spread and backwash effects of MSAs on population growth in non-metropolitan communities in the U.S. and compare results generated through three approaches. I find that the traditional nearest city model provides the most reliable results. This indicates that non-metropolitan places develop their local economies around the demands of the proximate market, rather than participating in more global markets. The results indicate that while commuting plays a major role in delivering spread effects into non-metropolitan areas, it is access to a focused market that is more significant. The results also show that while access to multiple MSAs may benefit a non-metropolitan place, more detailed information on economic linkages between places and cities is necessary to develop a more appropriately weighted model.

The results of this model show the anticipated sign on distance, which has the clearest theoretical antecedents. This approach shows spread effects from population growth and backwash effects from income change in the nearest city, which is consistent with previous research. In the nearest city and other approaches, the MSA and place-level control variables are generally significant and with the expected signs. The addition of Census Division dummy

variables strengthens the models and shows the well-known Frost Belt-Sun Belt migration patterns typical in the U.S.

In sum, this paper compares results of a spread-backwash model using three different approaches to conceptual measurement. Based on empirical findings, the nearest city model appears to be the most ideal specification, though potential advancements remain. One potential advancement is a model that could distinguish between the spread and backwash effects that act through commuting and those permitted by the flow of goods. A better approximation of the level of infrastructure that permits commuter and goods flows would also enhance future research in this area.

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Chapter 4: Detecting and Specifying Spatial Heterogeneity in Commuting Patterns

4.1 Introduction

At its most basic, suburbanization can be thought of as an increasing population density at increasing distances from a city center. This process is synonymous with the conversion of rural land to suburban or urban space, and with a spatial widening of the distribution of the labor force, if not of productive activity and employment. Describing the process of suburbanization in greater or more local detail, however, becomes more complex. The variables involved in individual households' decisions are diverse, ranging from family situation, accessibility to jobs, preference for urban and rural amenities, housing preference, and willingness to pay for such preferences in the form of prices or reduced wages. Furthermore, the spatial form of any given city, as well as its positioning relative to other cities, influences the relative attractiveness of residential locations.

Measuring spatial accessibility to jobs is one method of estimating the relative attractiveness of residential locations within regions. In this perspective, the most desirable residential locations are those from which residents have access to multiple areas of concentrated employment opportunities. In these areas, the likelihood of finding a job is higher, changing jobs is expected to be easier, search costs are lower, and finding jobs for both workers of dual-income households might be simpler. However, excess commuting will continue for at least two reasons. First, high accessibility of jobs in the residential area deters migration in favor of commuting (Elliason, Lindgren, and Westerlund, 2003). In other words, workers are resistant to abandoning a residential location where the anticipated job search cost is low, even if it means commuting in the short-run. Second, the ease of changing residential location varies based on the size and

vacancy rates of the residential areas (Rouwendal, 1998). For instance, it is much easier to change residential locations in a town with average vacancy rates (such that households can both sell their current home and find a suitable new home) than in a place like New York City, where the search for housing is notoriously difficult. In this illustration, someone who works in New York City may commute some significant distance to work when there are people who live much closer to his place of work, simply because the search cost of moving is high. In this perspective, workers will reside in areas with high accessibility to jobs, but excess commuting will continue.

Other methods of estimating or predicting the relative attractiveness of residential locations within regions come through more explicit attention to processes of suburbanization and exurbanization. The competing theories of deconcentration and restructuring debate whether suburbanization occurs as a shift in preferences regarding residential location and amenities combined with a diminishing cost of commuting (deconcentration), or in the outward movement of firms to capture lower operating costs (restructuring). Empirical studies generally favor deconcentration (see Fuguitt and Beale, 1996; Renkow and Hoover, 2000; see also Frey, 1993 for dissenting findings); both sides are considered in the literature review given below. In the deconcentration perspective, workers will reside in locations with suburban or rural amenities, from which commuting is possible.

Empirical work investigating deconcentration and restructuring tends to be non-spatial, assuming that entire regions are either deconcentrating or restructuring as a whole, and that the same mechanism of population change explains the shifting spatial structure relationship across the entire region. Yet there is plenty of theoretical and empirical work, as reviewed below, to support the hypothesis that regional spatial structure is being built and is changing unevenly across space at any given time. Some work on investigating residuals from migration models (a

popular approach to estimating deconcentration and restructuring) across space has been done (Fotheringham et al., 2000), and Khan et al. (2001) incorporate local amenities in a model of population and wage growth given economic growth in nearby counties. However, empirical work has not been done to investigate the significant variation in deconcentration and restructuring across space, construct a model specification that reflects that spatial variation, and tie its results to theory.

Geographically weighted regression (GWR) provides a means to understanding the nature of the relationship between variables across space (Fotheringham, Charlton, and Brunson, 1998). In this paper, I argue that GWR provides a unique function to the study of deconcentration and restructuring: it lets researchers disentangle the spatial extent of different mechanisms of commuting across a region. Unlike testing the residuals of OLS regression for spatial patterning, GWR allows me to evaluate the spatial patterning in the coefficients of each independent variable. It allows me to articulate sub-regions where particular mechanisms of residential turnover are prevalent.

By casual observation (as described in further detail below), it appears that during the 1990s the Chicago region experienced dramatic population change at its fringe. The outlying metropolitan counties were the fastest-growing segment of the region, and there is strong evidence of substantial migration across the urban hierarchy represented in the handful of cities near Chicago. This paper seeks to investigate the mechanisms driving this change across the collar counties between 1990 and 2000.

Modeling deconcentration and restructuring across space at the urban-rural interface will provide information relevant to rural development policy, sustainable development, and infrastructure planning. In rural development policy, the infrastructure developments that allow

deconcentration is the same infrastructure that allows spread effects via commuting from non-metropolitan places (e.g. Berry, 1970; Gessaman and Sisler, 1976; Moss, Jack, and Wallace, 2004; Partridge et al., 2007). Identifying the spatial variation in deconcentration and restructuring across a region will allow economic development policy to tailor regionally-focused policies for the rural areas that have substantial linkages to the metropolitan core and community-specific programs in places where spread effects are unlikely to occur (Henry, Barkely, and Bao, 1997). Relative to sustainable development, understanding the spatial variation of deconcentration and restructuring will aid in the development of urban growth management policies by identifying places that are most likely to experience rapid growth and the mechanisms that drive that growth.

The remainder of this paper follows in seven sections. The next section gives the analytical framework. This section sets up the theoretical framework for the measurement of deconcentration and restructuring by first reviewing the concepts of complementarity and substitution. Section three provides background literature and hypotheses of deconcentration and restructuring, substitution and complementarity, and dynamism in regions, with the central argument that these terms are extremes along a spectrum of more plausible scenarios. Section four gives an overview of the study region and the components of its growth between 1990 and 2000. In short, it is a complex region, with thirteen MSAs, four states, and outlying metropolitan counties growing faster than other areas of the region. Section five gives the form of the econometric analysis, with a review of Geographically Weighted Regression (GWR, used as an exploratory technique). Section six describes the data used and the transformations done to that data to optimize both measurement and model performance. Section seven presents the results of the GWR and the OLS model re-specified using the GWR output. Overall, the model shows

clear spatial heterogeneity in the mechanism of deconcentration over space. In the study region, there is a gradient across which households can choose different combinations of residential characteristics on which they maximize their household utility. The final section concludes the paper.

4.2 Analytical Framework

This section sets up a commuting framework based on the rationality of maximizing the net utility an individual captures by combining work and residence location decisions. Using Renkow and Hoover (2000) as a starting point, I assume that household utility is given by

$$U = U(X, H(\tau), L) \tag{1}$$

Where X is consumption of a composite good, H is consumption of housing services, and L denotes leisure, including the appeal or place stickiness of having family ties to an area. Following again Renkow and Hoover (2000), this utility function is subject to a budget constraint equating household earnings to household expenditures, including the cost of commuting.

The study of deconcentration and restructuring directly addresses this chapter's concern with understanding the mechanisms of explosive population change at Chicago's fringe. The most relevant set of hypotheses deals with the movement of people and firms outward from the nexus of a region. As briefly described in the introduction, the principle theories are deconcentration and restructuring. Deconcentration theory posits that with decreasing transportation costs, people can afford to act on the preference for more land, and so choose to commute to work. In restructuring, industry faces changing economic constraints and

opportunities that provide a motive to increase distance from the central city; workers follow (Audirac and Fitzgerald, 2003; Clark and Kuijpers-Linde, 1994; Renkow and Hoover, 2000).

4.3 Background

This section provides an overview of the literature on the theories of deconcentration and restructuring, substitution and complementarity (a popular method of measuring deconcentration and restructuring), and the dynamism inherent in changing regional spatial structure, which complicates the discrete notions of deconcentration, restructuring, substitution, and complementarity. A consideration of this literature supports the hypothesis that deconcentration and restructuring cannot be conceived of without a consideration of space.

Deconcentration and Restructuring

Though the texts cited in the introduction (Fugitt and Beale, 1996; Renkow and Hoover, 2000; Frey, 1993) are the most closely aligned with the subject matter of this paper, there is a much broader collection of literature around deconcentration and restructuring. An excellent review is provided by Audirac and Fitzgerald (2003) which, though it focuses on the role of information technology, provides a more than sufficient coverage of the terminology. This review draws heavily on the sources identified there, including direct quotations to introduce each term.

As Audirac and Fitzgerald introduce it, “In the deconcentration group...we find works in the human ecology tradition of urban sociology and microeconomic neoclassical approaches in location decision theories” (2003, p. 482). This theory is fairly straightforward: technology and infrastructure reduce the cost of travel and communication, allowing households to move to the

periphery of a region (Audirac and Fitzgerald, 2003). At the periphery, larger lots and homes are available, with the full range of bucolic amenities which are attractive for families (Rouwendaal and Meijer, 2001). Brian Berry (1973) was among the earliest scholars to discuss deconcentration. He posited its development on the compression of time (see also Fishman, 1990) and space, as permitted by technology, and the mobility of social classes, which would lead to increased education attainment and mobility. One final point worth mentioning is that at its root, deconcentration is a function of atomistic decision making about trade-offs between commuting, lifestyle amenities, and access to employment. This is in contrast to the restructuring school.

The restructuring school, on the other hand, “has its intellectual roots in Marxist political economy and regulation theories” (Audirac and Fitzgerald, 2003, p. 483). These authors go on to explain, “Since theories in this school are vastly heterogeneous, it can simply be said that they emphasize economic and spatial restructuring resulting from (1) technological change, which is the result of, and the transformational force affecting, the (capitalist) mode of production, and (2) the role of the state in shaping the conditions for economic growth (capital accumulation)” (p. 483). One of the more consistent themes in the restructuring literature is the transformation of the urban hierarchy from one based on global ports to one based on global centers of command and control with the spatial dispersion of standardized or “less intellectual” (Storper, 1997) activities and back-office functions (Audirac and Fitzgerald, 2003; Sassen, 1994; Sassen, 2002; Scott, 1988; Dunford and Kafkalas, 1992; Coffey and Bailly, 1992). Unlike the deconcentration literature, restructuring studies “reflect the regulation regimes and the interests of corporate and public-sector actors” (Audirac and Fitzgerald, 2003, p. 484).

Complementarity and Substitution

A popular conceptual measurement for deconcentration and restructuring is the relationship between in-migration and out-commuting within a jurisdiction (usually the county). A positive relationship between in-migration and out-commuting is called “complementarity;” the inverse is “substitution” (Evers, 1989; Renkow and Hoover, 2000). Conceptually, if households are moving into counties and continuing to work elsewhere (complementarity), deconcentration is occurring; the cost of commuting has been outweighed by the lifestyle amenities offered at the periphery. If households are moving into counties to replace commuting to those counties (substitution), then households are following the spatial movement of corporate decisions. Complementarity and substitution are conceptual measurements for the theoretical constructs of deconcentration and restructuring. The logic behind this approach is straightforward; within limits, it will measure the extent to which households move to take advantage of amenities at the urban fringe versus move to eliminate a commute. For a detailed discussion of this approach see Renkow and Hoover (2000) and Evers (1989).

Dynamism

Constructing typologies is an academic exercise that enables the analysis of empirical data but simultaneously mutes heterogeneity. In reality, deconcentration and restructuring and complementarity and substitution happen simultaneously within regions; as discrete concepts they are the polar ends of a spectrum of more plausible scenarios. There is both theoretical and empirical evidence of this.

Theoretically, there are many hybrid perspectives. Deconcentration and restructuring can be seen as simultaneous results of the interaction of information technology and development

(Amirahmadi and Wallace, 1995). Deconcentration suggests that workers move to the suburbs to take advantage of lifestyle amenities (e.g., Hirschorn, 2000). Restructuring argues that corporations move to make their businesses more profitable. A hybrid theory suggests that while the New Economy urges the reorganization of corporate structure, some firms choose to move to the periphery for the lifestyle amenities (Beyers, 2000), which is a distinctly atomistic approach to corporate decision-making (see also Henton and Walesh, 1998).

There is also a theoretical expectation that restructuring and deconcentration would be spatially heterogeneous. On the deconcentration side, spatial variation in lifestyle amenities provides an avenue for jurisdictions to compete for knowledge workers (Castells, 1996; Florida, 2000; Henton and Walesh, 1998; Hirschorn, 2000). On the restructuring side, the variation in the provision of information technology capacity, airports, and other transportation infrastructure make some peripheral locations more attractive than others as corporate locations (Kasarda, 2000; Ocelli, 2000; Feitelson and Salomon, 2000; Rodrigue, 1999). Spatial variation in lifestyle amenities and infrastructure provision are only two examples of the many potential forces that theoretically enable deconcentration and restructuring to happen with spatial heterogeneity.

Empirically, to some extent, there is evidence of all of these concepts: deconcentration (e.g. Renkow and Hoover, 2000) and restructuring (e.g. Frey, 1993); clear spatial heterogeneity in the relationship between migration and commuting within regions (Clark and Kuijpers-Linde, 1994); and the presence of both complementarity and substitution within a region, though the evidence for substitution is not statistically significant (Renkow and Hoover, 2000).

It is worth discussing the spatial heterogeneity in the migration-commuting relationship, as it is central to this paper. In their work comparing commuting within Southern California and the Randstad, Netherlands, Clark and Kuijpers-Linde (1994) describe Southern California as

having an “archipelago” of emerging and shifting urban centers “floating on the sea of urbanization” (p. 470). In this spatial structure type, the relationship between migration and commuting at the county-level is driven by the stage of emergence as polycentric structure; counties with recent population growth have higher out-commuting to reflect the temporal lag between residential and employment development in emerging urban centers. More established areas have stronger commuting within the county, with flows increasing to other counties as they emerge as urban centers. These findings suggest that within regions, it is less a question of whether deconcentration or restructuring are happening, but *which* is happening *where* and at *what time*. Depending on how established the urban center (suburb) is, it is witnessing first population deconcentration, followed by business restructuring which capitalizes on both the cheaper land and new labor supply in the suburb. The stage of deconcentration or restructuring may be observed in the magnitude of the regression coefficient for migration when the dependent variable is commuting.

4.4 Chicago, IL MSA Study Region

This paper focuses on the Chicago-Naperville-Joliet CMSA plus its surrounding non-metropolitan counties. Collar counties within a 110 mile distance of Chicago (Figure 4.1) were selected for study. Distance was measured with consideration of Lake Michigan; the line segments used to determine distance from Chicago went around rather than through the lake. This selection process yields a study region of 65 counties in four states, as shown in Figure 4.1. The selection is justified by its characteristics. Any sample other than the smallest selection of counties surrounding Chicago would include counties with obvious linkages to at least one other nearby MSA. The selection shown in Figure 4.1 extends far enough outward from Chicago to be

bounded by smaller MSAs, MSAs to which the Chicago fringe counties likely have linkages. Including this set of counties provides a coherent view of the relationship between commuting and migration for counties at the urban fringe outside Chicago.

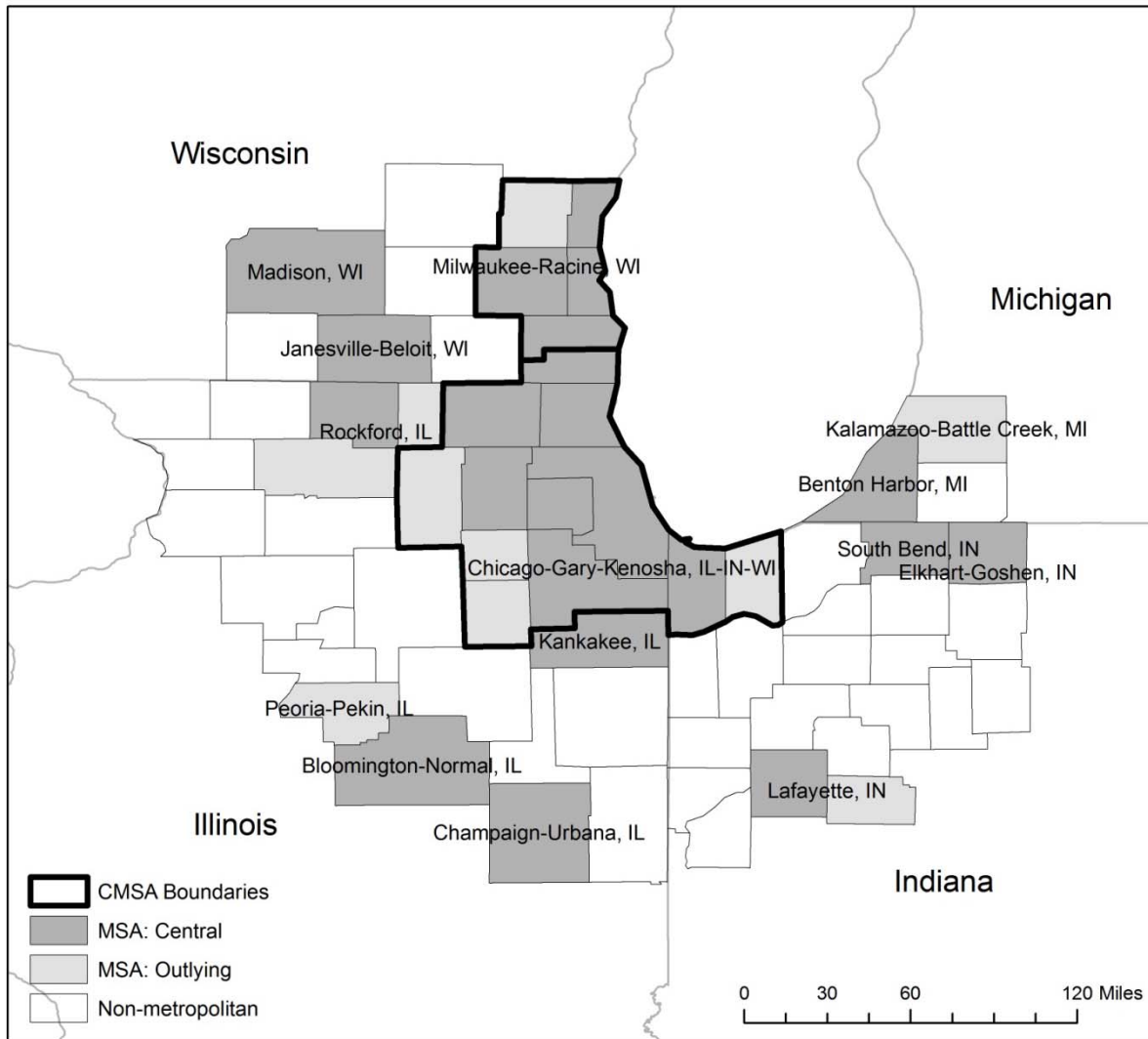


Figure 4.1: Study region

Although the study was originally conceived of as measuring the spatio-temporal changes in the commuting-migration relationship at the urban-rural interface outside Chicago, measurements along that border are made greatly more complex by other features of the region.

Of the 65 counties in the region, twelve are in the Chicago CMSA, five are in the Milwaukee-Racine, WI CMSA, and fifteen are spread across another eleven MSAs. Each of those MSAs exerts spread-backwash effects in addition to Chicago's economic engine. The area around Lake Michigan and Chicago is also heavily traveled via Interstate highways, which have the potential to provide (but do not guarantee) non-metropolitan counties with growth effects (Ashauer, 1989; Chandra and Thompson, 2000; Garcia-Mila and McGuire, 1992; Gessaman and Sisler, 1976; Weber, 1929), especially when those counties are near cities or are somewhat urbanized (Rephann and Isserman, 1994). Though the effects of highways were captured in the measurement of spread-backwash effects, it is likely that the density of infrastructure in the Chicago study region exceeds that of the national sample studied in Chapter 3, and thus its effects may be stronger.

Underscoring the need for this study, the outlying metropolitan counties of the region grew the fastest by a wide margin between 1990 and 2000, at 17.0% (Table 4.1); clearly there are enormous changes ongoing at the urban fringe. Through the 1990s, four counties in the study region converted from non-metropolitan status to "outlying metropolitan" status. The fastest-growing county in the region (McHenry, IL), converted from "outlying metropolitan" to "central metropolitan" status over the decade. Of the top ten fastest-growing counties in the region, four were central metropolitan, four were outlying metropolitan, and two were nonmetropolitan. A spatial presentation of population change is given in Figure 4.2. The strongest growth occurred to the west of Chicago and north into Wisconsin. Interestingly, while Chicago maintained its rank as the third largest city in the U.S. over the decade, the region as a whole and most counties in it (45 of 65) grew slower than the nation, which grew at 13.2% over the decade.

Table 4.1: Population growth in the study region, 1990-2000

	# of Counties ¹	1990 Population	2000 Population	% Change
Non-metropolitan counties	33	1,287,551	1,361,166	5.7%
Outlying counties	10	584,392	683,755	17.0%
Central MSA counties	22	11,230,000	12,348,884	10.0%
All study counties	65	13,101,943	14,393,805	9.9%

1--using OMB 1999 definition

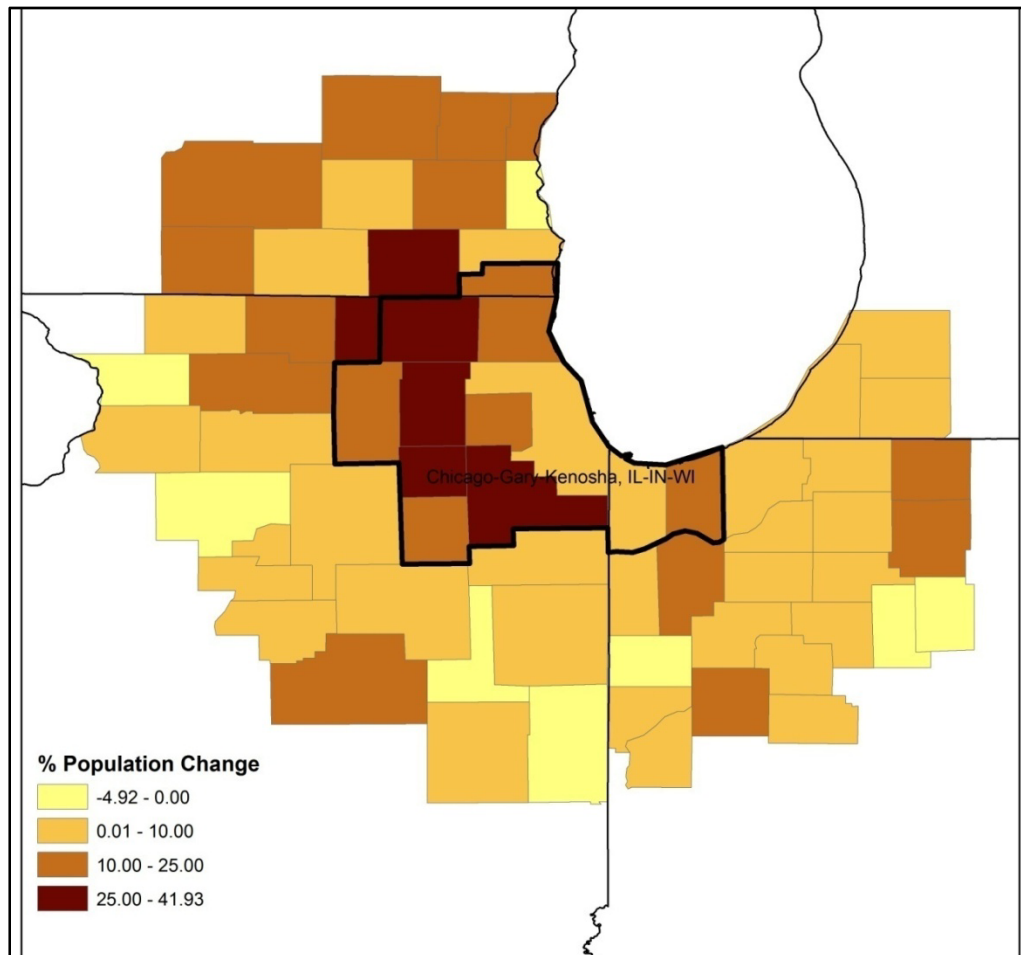


Figure 4.2: County Population Change, 1990-2000

Across the study region between 1990 and July 1999, the population grew by 1,245,416 net people through natural growth (births minus deaths) and lost 66,206 people on net via

migration. The region lost upwards of half a million people (net of -500,824) via domestic migration and gained (on net) 434,618 through international migration. Though these sources of change and their magnitudes seem surprising, in fact they are not unusual for mega-cities (populations over 2,500,000; Plane, Henrie, and Perry, 2005). In mega-cities, the net migration rate is positive *only* in the age bracket 25-29 years (Plane, Henrie, and Perry, 2005). It is therefore unsurprising that the Chicago CMSA median age is 33.9, or 1.4 years younger than the national median of 35.3. Migration characteristics, in general, have features specific to individuals and households in various stages of the life cycle. One key feature pertinent to the study region is that of household formation and childbearing, both of which encourage growth by natural causes and migration down the urban hierarchy (Plane, Henrie, and Perry, 2005). Evidence of this movement can perhaps be seen in the fact that households moving in the 1990s into Chicago were smaller and earn less than households moving out of the Chicago MSA (Yu, 2009). Stereotypically, young individuals or couples were moving to the city, started building careers and families, then out-migrating with higher incomes and larger households than when they arrived. Consequently, the roles of migration and commuting at the urban-rural interface, and at the interface of a mega-city and nearby smaller cities, become increasingly important.

In 1990, there were 6,167,932 workers who both lived and worked in the study region. Of those, 1,223,491 (19.8%) commuted across county lines within the study region. In 2000, those numbers expanded to 6,663,231 workers who both lived and worked in the study region. Of those, 1,558,551 (23.4%), which constitutes 17.4% of all region residents ages 18-64, commuted across county lines within the study region. That the percentage of workers commuting over county lines increased by 27.4% suggests that the spatial distribution of economic activity expanded during that time. It is more convincing when combined with the fact that four counties

in the study region converted from the OMB classification of non-metropolitan to outlying metropolitan during the 1990s, and that outlying counties were the fastest growing subset of counties in the study region (Table 4.1).

Given the substantially more robust empirical support for the theory of deconcentration over regional restructuring (see Fuguitt and Beale, 1996; Renkow and Hoover, 2000; see also Frey, 1993 for dissenting findings), it may seem likely that much of the spatial expansion of economic activity is done through commuting. Yet this is only part of the picture. An analysis of Bureau of Labor Statistics, Quarterly Census of Employment and Wages data from 1990 and 2000 shows strong growth in the number of establishments across the region, with the strongest growth in the outlying metropolitan counties (Table 4.2; using OMB 1999 definitions). Growth in number of private establishments easily outpaced population growth in each of the three types of counties. Though it seems likely that deconcentration is occurring, Table 4.2 also supports the informal observation within the region there is spatial heterogeneity in the degree of population deconcentration versus restructuring.

Table 4.2: Number of establishments by county type, 1990 - 2000

County type	Establishments in 1990	Establishments in 2000	Percent change
Nonmetropolitan	27,621	31,477	14.0%
Outlying metropolitan	10,789	14,707	36.3%
Central metropolitan	244,623	305,628	24.9%

A “back of the envelope” estimation easily demonstrates the magnitude of the economic consequences of commuting. Across the study region, the average earnings for the population ages 16+ with earnings was \$34,884 (Census 2000, SF3 Tables P84 and P86). Using that average earnings statistic, cross-county commuters within the region moved approximately \$54.4 billion

through the region in 2000. It is critical for municipalities to better understand the drivers of commuting to better capture a piece of that \$54.4 billion practice.

This study region offers several benefits. Though the inclusion of a second CMSA and eleven other MSAs in the study region complicates analysis, it also provides a rich context. For example, the complex region allows me to test hypotheses of the attractiveness of access to multiple cities from a residential location (Eliasson, Lindgren, and Westerlund, 2003). The selection of this region is also based on data availability, and the opportunity to work alongside students doing related work in the Regional Economics Applications Laboratory at the University of Illinois at Urbana-Champaign.

4.5 Econometric Analysis

The previous section described migration and commuting for the Chicago, IL MSA region for 1990 and 2000. This section outlines an econometric specification of those cross-county commuting trends and reviews the econometric methods used.

Empirical Model Specification

The empirical form specifies the variables believed to contribute to a household's decision to commute or migrate when trying to maximize household utility given budget and time constraints (as given in equation 1). These variables include place-specific housing considerations, distance (time constraints) measurements between home and work, a measure of place stickiness (ethnic concentration), and potential to increase wages by commuting. The empirical form given is

$$C_{ij} = f(\Delta W_{jt}, \Delta H_{jt}, \Delta Q_{jt}, E_i, D_{ij}, M_i) \quad (2)$$

Where

C_{ij} = net number of workers commuting from county i to county j , normalized by the employed population of county i (this is a departure from Renkow-Hoover)

ΔW_{ji} = wage in county j minus wage in county i

ΔH_{ji} = standardized housing cost in county j minus county i

ΔQ_{ji} = four-year college degree attainment rate in county j minus county i

E_i = concentration of ethnicities in county i

D_{ij} = distance between counties i and j , using population-weighted centroids

M_i = net migration into county i in the previous period, normalized by the population in county i in the previous period

I normalize net commuting by the employed population of county i . This is done to scale the value of commuting. The wage, housing, and distance variables are included as significant push and pull factors in the decision to migrate or commute. A commuter should logically want to maximize income while minimizing housing costs and distance traveled. I also include a measure of the difference in educational attainment between counties. This measure is calculated by taking the percent of the population with at least a bachelor's degree then subtracting county j 's score from that of county i . I do this to introduce a control for the skill level available in the labor market, to control for spatial mismatch of jobs to skills. A measurement of this differential is particularly necessary in situations where there is significant cross-commuting, for example, when central city residents work in the suburbs and suburban residents work in the central city.

I include a measure for a key amenity that cannot be assumed to be capitalized in the housing and wage prices—family ties. This aspect of “place stickiness” is proxied by a Simpson

index of ethnic concentration in each county, which measures the probability that “any two members selected at random from a population will belong to different groups” (Plane and Rogerson, 1994, p. 302). It is assumed that people like being near other like people, to enjoy ethnic customs, family bonds, and a sense of commonality in community. This is not an argument for segregation, but rather for the value of family and the idea that absolute integration is also unfavorable.

Finally, rather than using the difference in median housing costs between counties, I calculate a difference in housing costs for comparable units, by using HUD’s Fair Market Rent statistics. This marks a significant departure from the literature, where traditionally housing prices have been compared across geographic units at the median, without respect to characteristics (e.g. McMillen, 2003). Using Fair Market Rents allows me to control for the size and general quality of the housing unit. This is important considering the key demographic that moves into and out of mega-cities—young people and new households, respectively. For a new household, housing units of equal price in a central city and a suburb or smaller city are absolutely unequal, with unit size being one of several key distinctions. A hedonic housing index would be ideal, but the data is not available at the county level.

On a substantive level, this paper acknowledges that the tools to measure the variation in the commuting-migration relationship are newer than much of the research in this area, and their application to this research question is novel. There are questions left unanswered in existing research; are the statistically insignificant occurrences of negative migration coefficients indicative of undetected, spatially distinct causal mechanisms in the commuting-migration relationship? How can research on the relationship between commuting and migration better inform scholars on the mechanisms of population growth at the urban-rural interface? I address

these unanswered questions by first using GWR, which gives a detailed view of the spatial variation in the relationships between commuting and the independent variables listed above. Output from the GWR model will be incorporated into a clustering algorithm, which will define based on the GWR coefficients discrete sub-regions within the study area. I then interact dummy variables for each region with the independent variables in an OLS model to verify whether the spatial patterning in the GWR betas is significant in modeling commuting across the region.

The econometric analysis is carried out in two stages. The first stage uses GWR. The coefficients of the GWR are used as input in a clustering algorithm which defined sub-regions in the study area. Dummy variables for the sub-regions are interacted with the variables in the empirical specification and re-tested via OLS to test the hypothesis that there is statistically significant spatial variation in the commuting-migration relationship.

Geographically Weighted Regression (GWR)

GWR is a technique used “to examine the spatial variability of regression results across a region and so inform on the presence of spatial nonstationarity” (Fotheringham, Charlton, and Brunson, 1998). Its general form, GWR can be expressed as:

$$y_i = a_0 + \sum a_k(u_i, v_i)x_{ik} + \varepsilon_i \quad (3)$$

Where u and v are coordinates of the i th point, allowing a continuous surface of parameter values (Fotheringham, Charlton, and Brunson, 1998, p. 1907). This technique produces localized regression diagnostics. To allow calibration of the model, points nearer to point i are given more weight in the estimation of the parameter value for point i ,

$$\hat{a}(u_i, v_i) = [X^T W(u_i, v_i) X]^{-1} X^T W(u_i, v_i) y \quad (4)$$

One technical consideration of this approach is that it is meant to model values at i . However, the dependent variable used in this paper is the commuting flow between ij pairs of counties, meaning there are multiple data points for each sending county i . A hierarchical approach may be more ideal. However, the GWR is used in this paper to delineate sub-regions on which to test the spatial heterogeneity of the mechanism of deconcentration. It is not used to draw conclusions. The statistical significance of sub-regions in the final specification is sufficient evidence that the GWR has functioned satisfactorily for the purpose of this research.

McMillen (2004) briefly reviews the GWR concept and different perspectives on its use. From a conceptual perspective, there are two characteristics that distinguish GWR from other parametric and nonparametric approaches. Unlike nonparametric approaches, GWR does not focus on nonlinearity in independent variables, but rather is appropriate for situations of linearity between the dependent and independent variables at a given location. Second, and perhaps its hallmark, GWR estimates the spatial variation in the coefficient for each variable. This is especially helpful when it is unclear whether: (1) different socioeconomic, demographic, or related situations cause different commuting mechanisms, which could be detected by finding spatial patterning in the average x values or by spatial patterning in the (average) βx values by county i (where observations are ij pairs of counties), or; (2) the model is either misspecified or underestimating the value of place.

This latter point deserves attention. In his review McMillen (2004) provides a clear articulation of the principal difference between applied geographers and applied economists. The former, he says, see spatial variation in regression coefficients as “consistent with post-modernist beliefs on the importance of place and locality as frames of understanding...behavior” (a direct quote from Fotheringham, Charlton, and Brunson, 2002). Applied economists, on the other

hand, believe GWR helps to detect model misspecification; they dismiss out of hand that the price of a standard good (his example is a garage) truly varies over space, but rather can be modeled based on its qualities and the qualities of nearby amenities. As he writes, “GWR is a useful regression diagnostic; we have more faith in our specification if the results are not altered by the use of GWR. If the results change, it is an indication that more investigation is in order, not that the price of a garage is truly different in different parts of a city” (2004, p. 556).

In the case of modeling commuting in a large, city-focused region, I argue that there is growing room for both arguments. There *is* a literature speculating that households choose residential locations for the intangible character of the place (Castells, 1996), and similarly that firms develop organizational structures that respond to local contexts (Belussi, 2000). However, it is also true that the growing literature on and tools to measure place-based amenities is growing (e.g., Ganning and Flint, forthcoming). This paper takes the first of two steps that are critical in fully developing our understanding of mechanisms of commuting and thus of population growth mechanisms at the urban-rural interface: (1) detecting the presence of and geographic extent of “local contexts” which influence commuting within a region and (2) more fully investigating those contextual elements. The latter may be better suited to survey-based research, qualitative inquiry, or case study research, which is beyond the scope of this paper.

4.6 Data

This paper relies primarily on three databases: the Census of Population and Housing (2000), the Census Transportation Planning Package (CTPP 2000), and migration data from the Internal Revenue Service (IRS, 1990-2000). Though the Census databases provide information for a finer level of geography, the IRS files are available only at the county level. Additionally,

in CTPP data there is a trade-off between spatial resolution and data disclosure, making difficult an analysis where each place of residence and place of employment pair are assessed separately. Therefore, the county is the unit of observation for this study. The full range of regression variables by data source used is given in Table 4.3. Additionally, population at the block group and county levels for 2000 was used to establish population-weighted centroids for each county.

Table 4.3: Variables for Geographically Weighted Regression

Variable	Definition	Source
C_{ij}	Net commuting from county i to county j, standardized by the employed population of county i	CTPP 2000
W_{ij}	Difference in wages between county i and county j.	Bureau of Economic Analysis, 2000
H_{ij}	Difference in the Fair Market Rent of a 2-bedroom apartment between county i and county j	HUD Fair Market Rent
Q_{ij}	Difference in four-year college degree attainment rates between county i and county j	Census 2000
E_i	Concentration of ethnicities in county I, measured using a Simpson index ⁴	Census 2000 (SF3, Table PCT 18)
D_{ij}	Distance between counties i and j, with distance measured from the block group population-weighted centroid of each county	Census 2000, and ArcMap 9.3
M_i	Net migration into county i in the previous year, normalized by population in the previous year	IRS county-to-county migration tables, 1998-1999

⁴ $S = 1 - \sum_{k=1}^n (P_k / P)^2$

The wage data represents wages at the place of employment rather than the place of residence. This figure is the relevant one in modeling commuting rates since people commute to earn a wage that is offered somewhere other than the home county. Optimizing household utility is a combination of residential and work location choices, the latter of which is based largely on wage and availability of employment suitable to one's skill set. College education attainment includes all people ages 25+ living in a place who have earned a four-year degree or higher; those with some college or associates degrees are not counted as having attained a four year degree.

The difference in housing costs is controlled for by comparing the Fair Market Rent of two-bedroom apartments using data from the Department of Housing and Urban Development (HUD). Comparing housing costs in county-level research has long plagued researchers. Data that provides enough information to construct true hedonic housing price indices are generally not available at the county level.⁵ The HUD data has the distinct advantage of comparing equivalent housing units across space. The HUD data is also favorable for its continuity, though this paper does not take advantage of that feature; it is available for every year between 1983 and 2009, with changes in calculation methods clearly identified.

I began by limiting the data set to the ij county pairs that had non-zero net commuting, and from those selected only the observations with positive net commuting, as is established in the literature to avoid selection bias (Renkow and Hoover, 2000). I then limited the data set again to include only ij pairs that are neighbors in a second order (first order inclusive) queen weights matrix. The weights used to determine those pairings was developed in GeoDa. Invoking a

⁵ Such information is publicly available for PUMAs, which sometimes correspond to counties, but often encompass several counties, making analysis difficult. Information regarding house size, sales price, and other characteristics can sometimes be obtained from housing authorities or local Realtor associations. In those cases, that data is preferable to the rental cost information used here.

spatial limit also helps to eliminate observations with commute flows so small as to be within a reasonable margin of error. Finally, the model uses the log of net commuting as its dependent variable. This transformation was necessary to meet the assumption that the relationships between the dependent and independent variables be linear. After limiting the data to positive net commute observations within 2 neighboring counties, the data set includes 388 *ij* pairs in 2000. The analysis was carried out using R. I used the function `gwr.sel (spgwr)` in R to select the bandwidth, which is 0.8638697 decimal degrees.

4.7 Results

Geographically Weighted Regression

It should be said that improving on the existing OLS model of commuting flows will be difficult. Not only do Renkow and Hoover (2000) report reasonable strength in their OLS models, but the straight OLS model of commuting near Chicago is quite strong (Table 4.4). These results are shown with White-corrected standard errors (White, 1980; R code for White correction by Gianfranco Piras and provided by Professor Kathy Baylis). The model did not show multicollinearity. The variables that are common between this and the Renkow and Hoover (2000) approach show the same signs, giving a measure of external validity.

Table 4.4: OLS results from basic model, 2000

	coefficients	White s.e.	Sig.
	2.452556554	1.42E+00	*
Dij	-0.107268145	4.52E-03	***
Qij	3.620464959	8.08E-01	***
Ei	-0.467319873	1.64E+00	
Hij	0.005004315	7.30E-04	***
Mi	0.254360909	7.55E-02	***
Wij	7.46119E-05	1.40E-05	***
Adjusted R ² : 0.6656			
F-statistic = 129.4; p-value = 2.2e-16			
*** p<.01; ** p<.05; * p<.10			

The data was then testing using a GWR, the coefficients of which were used to cluster the sending counties (*i* of the *ij* pairs) into six groups. I chose to use six groups because (when compared to other numbers of clusters) the sub-regions created are generally spatially coherent. Figure 4.3 below shows the sub-regions created by running a fuzzy clustering algorithm (using R) on the GWR coefficients. Only 60 of the original 65 counties are shown here. This is intentional, as the other five (including Cook County, IL) are not the positive half of the net commuting relationship with any neighboring (as defined by the weights matrix) counties.

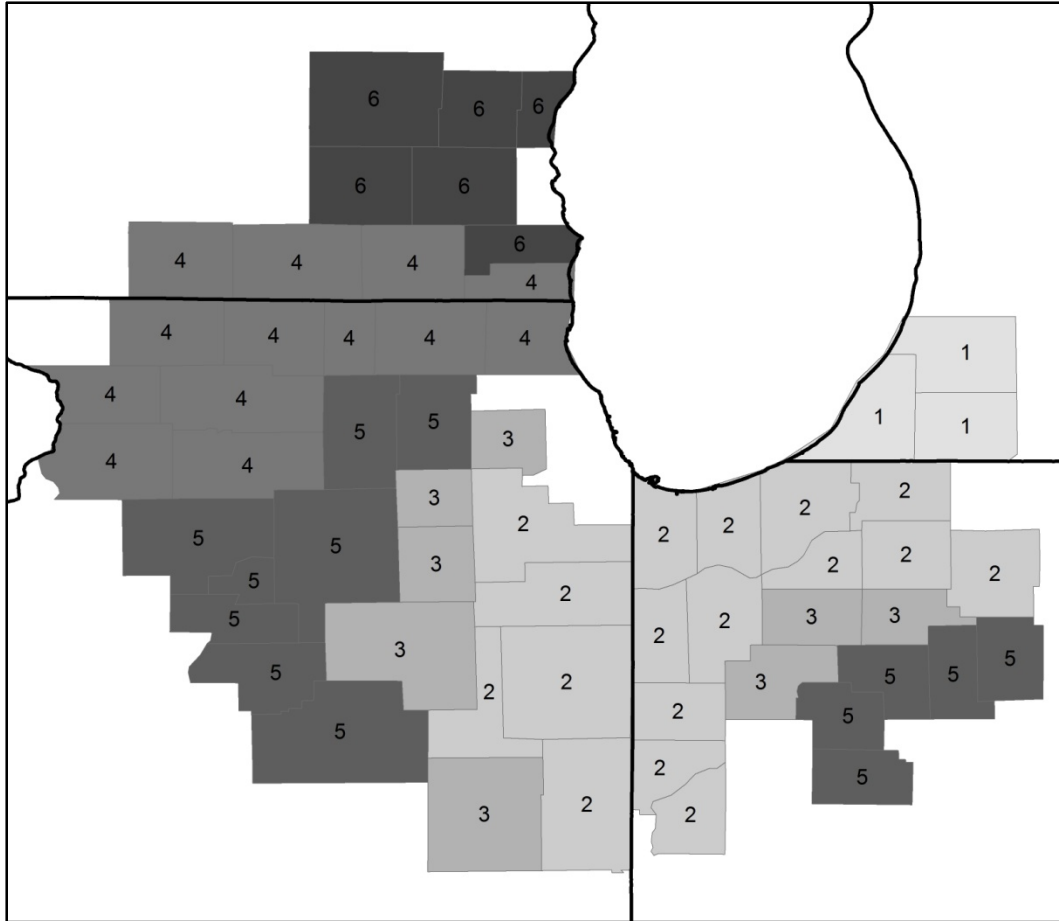


Figure 4.3: Sub-regions created by clustering the GWR coefficients

Respecified OLS Model

Using Region 1 as the comparison group, dummy variables for each region were interacted with each of the seven variables in the OLS given in Table 4.3, and put into a new OLS regression model. After some modifications, the final specification was selected. Results are given in Table 4.5, below. Variables are abbreviated as given in Table 4.3, and supplemented with “Fx” which refers to sub-region number 2-6 (sub-region 1 is the comparison group), as shown in Figure 4.3.

Table 4.5: OLS output with sub-regional dummies

	coefficients	White s.e.	Sig.
	-8.84E-01	4.63E-01	*
DijF2	-1.14E-01	8.58E-03	***
DijF3	-9.59E-02	1.05E-02	***
DijF4	-1.16E-01	1.02E-02	***
DijF5	-9.35E-02	8.98E-03	***
DijF6	-1.04E-01	1.34E-02	***
HijF2	6.23E-03	1.52E-03	***
HijF3	6.99E-03	2.07E-03	***
HijF4	6.81E-03	1.40E-03	***
HijF5	2.74E-03	1.12E-03	**
HijF6	-2.32E-03	4.11E-03	
QijF2	2.31E+00	1.70E+00	
QijF3	4.15E+00	1.64E+00	*
QijF4	2.06E+00	1.88E+00	
QijF5	6.14E+00	1.57E+00	***
QijF6	3.26E+00	2.90E+00	
WijF2	1.15E-04	3.76E-05	***
WijF3	-3.90E-06	3.93E-05	
WijF4	6.78E-05	2.32E-05	***
WijF5	4.72E-05	2.68E-05	*
WijF6	1.75E-04	5.46E-05	***
EiF2	3.50E+00	6.82E-01	***
EiF3	2.66E+00	7.94E-01	***
EiF4	3.76E+00	7.59E-01	***
EiF5	2.86E+00	7.34E-01	***
EiF6	3.85E+00	9.66E-01	***
MiNF2	1.55E-01	1.15E-01	
MiNF3	5.50E-01	1.73E-01	***
MiNF4	2.96E-01	1.91E-01	
MiNF5	1.92E-01	2.13E-01	
MiNF6	1.06E+00	4.51E-01	**
Adjusted R ² = 0.6442			
F-statistic = 24.35; p-value < 2.2e-16			
*** p<.01; ** p<.05; * p<.10			

Table 4.5 clearly indicates the statistical significance of the spatial heterogeneity of mechanisms of commuting across the study region. There are several conclusions evident in Table 4.5 which warrant interpretation and discussion, most notably the consistency of signs and variation in coefficients across regions.

The consistency of signs for any given variable across the five regions (where sub-region 1 was the reference region) was unexpected and lends significant credibility to the hypothesis that even diverse regions tend to deconcentrate and/or suburbanize as regions, even if the extent of that deconcentration is uneven across space. In both Renkow and Hoover (2000) and in early exploratory work for this manuscript, a statistically insignificant but negative sign on in-migration was found for some types of counties in some years. This suggested that breaking the region down into sub-regions might reveal pockets where the mechanism of commuting is drastically different, yet this has proven not to be the case. All of the signs are consistent and in the hypothesized direction in Table 4.5. It is interesting, however, that the sign on ethnicity (E_i) changed between the standard OLS and the respecified OLS given in Table 4.5, and the variable became statistically significant. This signals that simpler models that pool counties into one large region or distinguish them based on the discrete notions of “urban” and “rural” are muting the significance of this variable across space. Breaking a region into sub-regions paints a more complete picture of the gradient in commuting mechanisms across space.

As expected, the sign on the migration term is positive. Unexpectedly, the migration term is statistically significant for only two of the five sub-regions (Table 4.5). The coefficients of those two sub-regions, however, are telling. In sub-region 3 the coefficient on migration is double its value for sub-region 6. This indicates that while both sub-regions are undergoing population deconcentration, that process is much more pronounced in the Illinois outskirts of Chicago than in the northern outskirts of Milwaukee.

It is important to ask if the results shown in Table 4.5 so clearly indicate the significance of spatial heterogeneity in mechanisms of commuting across space because the \bar{x} values vary, because the coefficients vary, or due to an average effect. Using the county-level output

from the GWR, I calculated (using GeoDa) the Moran's I values for the β , \bar{x} , and $\beta\bar{x}$ terms for each independent variable (Table 4.6). Overwhelmingly, it is an average effect that drives the significance of the model shown in Table 4.5. It is both that coefficients vary across space *and* that the values of independent variables vary across space. This indicates that more investigation into the mechanisms of commuting is warranted (McMillen, 2004). Though the coefficients may be biased toward having a spatial pattern by virtue of having been created through a GWR, the GWR was constructed based on distance weighting, while the Moran's I is calculated using a Queen-based weights matrix.

Table 4.6: Moran's I values for GWR output

	β	\bar{x}	$\beta\bar{x}$
Dij	0.9139***	0.3594***	0.2367***
Hij	0.7319***	0.2697***	0.2664***
Qij	0.8256***	0.1059*	0.1587**
Wij	0.9208***	0.023	0.0268
Eij	0.9075***	0.5148***	0.9046***
Mi	0.9110***	0.2192***	0.2693***

*** p<.01 ** p<.05; * p<.10 (pseudo p-values)

Tables 4.5 and 4.6, taken together, clearly reveal that there is spatial heterogeneity in the drivers of the commuting-migration relationship, and perhaps most importantly, some drivers of that relationship are not visible in non-spatial models, as the ethnicity variable shows.

4.8 Conclusion

This research used the exploratory method of GWR to probe the spatial variation in the determinants of county-level intra-regional commuting over time and detect areas that deserve further research in the literature. In its simplest interpretation, this work has confirmed the earlier conclusion that a pattern of suburbanization can be seen across an entire region. However, this

work adds nuance to that finding by applying a statistical technique which post-dates the bulk of research on this topic. This work indicates that the degree of suburbanization varies across a region and that there is spatial patterning in the regression coefficients, signaling the need for more in-depth understanding of commuting mechanisms.

These results point to the need for increased research in the areas of residential amenity measurement for urban regions, as well as to the different but potentially equal (given variation in households' calculations of utility) pecuniary benefits of living in the urban core. This work could be approached through hedonic housing analysis (if adequate data were available) or through survey research, to name a few possibilities. This work must emphasize and draw on the observation from this work that the notions of "explosive population growth at the urban-rural fringe" and clean distinctions between deconcentration and restructuring are artificial. The results clearly indicate a gradient across the region, where tradeoffs between space, accessibility, and other variables are made. The GWR output does not delineate an urban and a rural, a "young peoples' community" or a "dual-income household" community. It shows a gradient across which households can choose the amenities and features that will maximize their utility in many combinations of methods.

In conclusion, updated econometric tools now enable the advancement of our understanding of mechanisms of commuting. There is a regional gradient across which different features of residential space are given higher and lower premiums, appealing to individuals wishing to maximize utility individually. Estimating a commuting function based on distance or crude categorization of counties over-simplifies and obscures drivers of the decision to commute or migrate. This perspective embraces on one hand a post-modernist perspective that individuals seek to combine different bundles of goods in unique ways which could include intangible place

qualities, and on the other hand embraces the applied econometric perspective that finding statistically significant coefficients across a region points to a model misspecification. In any case, the toolbox now available to spatial econometricians demands that we reject what is clearly an over-simplified depiction of commuting in regions.

4.9 Bibliography

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Chapter 5: Conclusion

This chapter will summarize and synthesize the three substantive chapters of this dissertation. I will begin by summarizing the main conclusions of each and then in section 5.2 will synthesize those findings into a narrative.

5.1 Summary of Chapters

This dissertation focuses on mechanisms of population growth at the urban-rural interface. The three substantive papers focus on that theme and inform on it from different perspectives. All three papers use a common sample of 276 MSAs (and CMSAs) from across the country. The first paper implements a measure of intra-regional spatial structure that had been developed and tested for use in the Netherlands and tests the validity of the measure by testing it against a range of hypotheses regarding spatial structure and socioeconomic trends, as given in the literature. That paper served as background and database-building work for the second and third papers. The second paper investigates spread and backwash effects (positive and negative effects of urban proximity, as measured through population change) for the sample of 276 MSAs on nearly 2,170 non-metropolitan communities (U.S. Census places) between 2000 and 2007. The third paper studies mechanisms of commuting within an urban-focused region experiencing rapid population growth at the urban fringe.

In the paper Chapter 2, I found that the van der Laan (1998) measure of spatial structure found partial but not universal support when tested against existing theories of about spatial structure and measures of socioeconomic status and demographics within regions. I found that regional demographics and some contextual characteristics are linked to spatial structure at statistically significant levels. The VDL measure N1, which measures traditional commuting,

found external validity. However, detecting polycentric spatial structure and relating it to theory proved more complex, revealing gaps in our understanding of both the mechanisms of polycentricity and the timing of its formation relative to its drivers. Among the more interesting findings of this chapter is that larger cities tend to have lower shares of commuters going from suburbs to central cities. This finding supports the hypothesis that the largest MSAs will have market-driven polycentricity, developing an “urban archipelago” (Clark and Kuipers-Linde, 1994). This suggests that polycentricity is an on-going process, happening in tandem with the spatial widening of a growing region’s economy.

In the paper “Spread and Backwash Effects for Non-metropolitan Communities in the U.S.,” I estimated the extent of pure distance effects of urban growth and tested the hypothesis that non-metropolitan places experience spread and backwash effects from multiple cities. I discovered that in the United States, a non-metropolitan place is never far enough away from a city to experience population growth effects gained by further isolation. The idea that after some distance a place is insulated from backwash effects simply does not play out using this data. I also revealed that though the ability to commute to a city is an important ingredient in non-metropolitan population growth, economic linkages to cities, and most importantly to the nearest city, play a more important role. This indicates that rather than participating in global markets, non-metropolitan places are used as suppliers of goods for neighboring cities.

In the third paper, “Detecting and Specifying Spatial Heterogeneity in Commuting Patterns,” I specified a spatial model of commuting within a region and discovered a large discrepancy between conclusions drawn from non-spatial versus spatial models of commuting. Most notably, I discovered spatial heterogeneity in both the values of the right hand side variables *and* in the coefficients. Also, I found that a measure of ethnic concentrations is not a

statistically significant determinant of commuting in a non-spatial model, but becomes significant in a spatial model (where ethnicities are concentrated, people more often choose to commute rather than to migrate, presumably to stay close to family). Overall, the fit of a spatial model is roughly similar to that of the non-spatial model, but the conclusions drawn vary significantly, and the coefficients estimated for sub-regions within the study area vary at statistically significant levels. This research has shown that misspecifications in previous models lead to potentially inaccurate conclusions. The present research suggests that theoretical distinctions between urban and rural, and the so-called drastic change at the interface, are oversimplifications of a region that has sub-regions. These sub-regions create a gradient of potential combinations of characteristics and amenities by that are considered by consumers to maximize household utility based on their individual tastes. Future work remains to be done around both the qualitative and quantitative determinants of estimating household utility.

5.2 Synthesis

These three papers raise questions about both existing theory and empirical findings, suggest hypotheses for further research, and contribute to methodological advancement in the study of population growth at the urban-rural interface. In this sub-section, I will synthesize the conclusions of the three papers into one narrative.

This dissertation has supported many hypotheses and previous research findings. Perhaps most consistently, I have found that the process of spatial expansion of economic activity works first by the expansion of residential locations, then by enlargement of population in the fringe county, and finally by growth in job opportunities in that county. All three papers support this finding. This is consistent with the deconcentration hypothesis, but puts into relief the fact that

deconcentration is only an initial stage in the spatial expansion of economic activity. Where deconcentration is happening, urban spatial structure is changing. From a policy perspective, it is important to detect early commuting patterns from the budding fringe counties and enhance the efficiency of those commuter flows, as they are likely to remain stable in pattern but increase in volume as the residential population of the county expands. As employment opportunities grow, the transportation focus will have to expand to allow commuting from other residential areas, fully integrating the county into the urban archipelago.

The new insights and hypotheses gleaned, however, are much more interesting, and there are several. The single clearest lesson learned from this dissertation is the importance of taking a regional perspective in planning. Chapter 2 illustrates the incredible mobility of labor between city and suburbs, and among suburbs. Chapter 3 clearly demonstrates the importance of linkages between city and countryside. Chapter 4 shows the fallacy in assuming that counties can be divided into small pools on the basis of single variables such as “urban” and “rural.” Instead, households maximize utility by choosing a location along a gradient of sub-regions that offer many different combinations of amenities and features, according to a household’s taste. In all of these examples, it is the region that grows or declines together. Though central cities historically played substantial roles as the engines of growth, this research clearly demonstrates the power of the regional engine instead.

Several implications for policy can be drawn from these conclusions. First, road construction should focus on connecting suburbs not only to the central city, but also to other suburbs, and that early commuting patterns emanating from budding residential areas should be given significant weight in determining future infrastructure needs. Second, if a region has a pro-growth vision, then planning should facilitate that growth rather than respond to it. Preempting

the need for infrastructure as the spatial range of economic activity expands can be facilitated using concepts advanced in this dissertation.

5.3 Closing

In closing, this dissertation has addressed two mechanisms of population growth at the urban-rural interface, and among other things detected that even the phrase “urban-rural interface” may be an over-simplification. This dissertation has paved the way for a tremendous volume of future work, including work around the process of polycentric evolution, the spatial extent of economic linkages for non-metropolitan places and the role of ethnic ties in the decision to commute or migrate within a region, to name a few topics. It has been my hope that this work would effectively inform rural development theory and policy, and I believe I have made significant strides in that direction and have established a research agenda around these themes.

Appendix

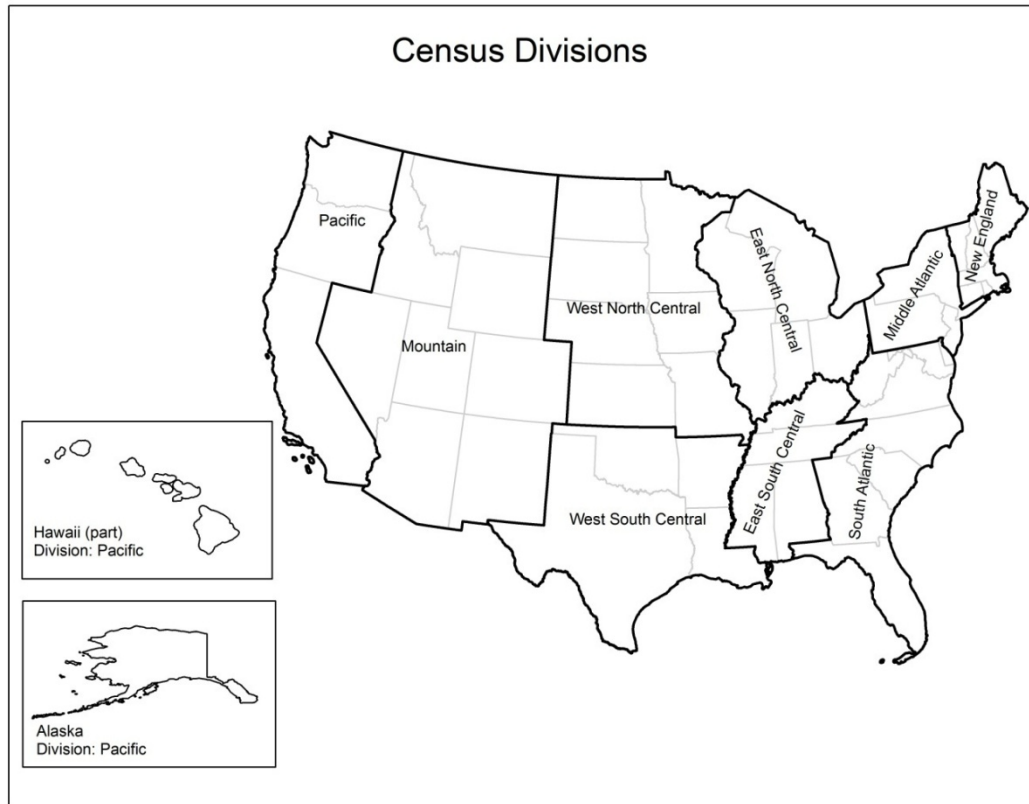


Figure A1: Census Divisions

Acronyms:

NE: New England

ESC: East South Central

PCF: Pacific

MNT: Mountain

WSC: West South Central

SA: South Atlantic

ENC: East North Central

MA: Middle Atlantic

WNC: West North Central

Table A1: Variables in analysis

Variable name	Data source	Description
<i>Key Variables</i>		
Log of population density	Census 2000	Using land area only, population per mile squared
Distance to nearest central city	Census 2000 TIGER/Line shapefiles, ArcMap 9.3	Used x, y coordinates to calculate the Euclidean distance between each non-metropolitan place and the first central city for each MSA
Access Total	Census Transportation Planning Package, 2000	Percent of non-metropolitan place commuters who work in an MSA
MSA-level population and population change	Census 2000 and Census Bureau Population Estimates, 2007	Level variable is divided by 1000
MSA-level income and income change	Bureau of Economic Analysis, REIS Tables	Per capita personal income, 2000 and 2007. Level variable is divided by 1000

<i>Place-level controls</i>		
Non-white	Census 2000	Percent of the population reporting multiple races or any non-white race
Elderly	Census 2000	Percent of the population that is age 65 or older
Education attainment	Census 2000	Percent of the population age 25+ that has at least a bachelors degree
Labor force participation rate	Census 2000	Percent of the population age 16+ that is in the labor force
Unemployment	Census 2000	Percent of the population that is in the labor force and unemployed
Urban	Census 2000	Percent of the population that is classified as urban
<i>MSA-level controls</i>		
Elderly	Census 2000	Percent of the population that is age 65+
Labor force participation rate	Census 2000	Percent of the population ages 16+ that is in the labor

		force
Afford	Census 2000	Percent of households paying less than 35% of monthly income on selected housing costs
Non-white	Census 2000	Percent of the population reporting multiple races or any non-white race
Foreign	Census 2000	Percent of the population that is foreign born
Education attainment	Census 2000	Percent of the population age 25+ that has at least a bachelors degree
Industry Mix	Census 2000, American Community Survey 2007	Sum of shares of employment in each industry multiplied by its national growth rate from 2000 to 2007. 13 industries used.