Does the New Economic Geography Explain U.S. Core-Periphery Population Dynamics?

Mark Partridge[1]
Dan Rickman[2]
Kamar Ali[3]
M. Rose Olfert[4]

March 21, 2006

Paper prepared for the 45th Annual Meetings of the Southern Regional Science Association
March 30-April 1, 2006
St. Augustine, Florida

Abstract

The New Economic Geography (NEG) was motivated by the desire to formally explain the emergence of the American urban system. Building on Central Place Theory's urban lattice of successively larger centers serving the rural agricultural hinterlands and smaller centers, the NEG incorporates market potential, growth shadows, product variety, and input-output externalities. Although the NEG has proven useful in explaining the development of the American urban system, few empirical studies investigate its success in explaining current population dynamics in a *mature* urban system, particularly for rural hinterlands and small urban centers. This study utilizes an extensive spatial database to explore whether proximity to higher-tiered urban centers affected 1990-2000 U.S. county population growth. Rather than growth shadows, the results suggest that larger urban centers promote growth for more proximate places of less than 250,000 people. However, among urban centers greater than 250,000, there are relatively few spatial interactions. Generally, NEG explanations only partially explain current core-periphery population dynamics, suggesting a need for a broader framework.

1. Department of Agricultural Economics, University of Saskatchewan and Canada Research Chair on the New Rural Economy. 51 Campus Drive, Saskatoon, SK, S7N 5A8, CANADA. Phone: 306-966-4037; Fax: 306-966-8413; Email: mark.partridge@usask.ca, webpage: http://www.crerl.usask.ca.
2. Department of Economics, Oklahoma State University, Stillwater, OK 74078. Phone: 405-744-1434, Fax: 405-744-5180. Email: dan.rickman@okstate.edu.
3. Department of Agricultural Economics, University of Saskatchewan. E-mail: kamar.ali@usask.ca
4. Department of Agricultural Economics, University of Saskatchewan. Email: rose.olfert@usask.ca

Acknowledgements: We thank Jordan Rappaport and Taisuke Nakata of the Federal Reserve Bank of Kansas City for generously providing Stata code for the GMM estimation.

1. Introduction

The interrelationship between major urban centers and their rural fringes is one of the most visible features of the expanding American urban landscape. Responding to technological, economic, and quality-of-life stimuli, households regularly relocate to areas that offer greater net utility. The resulting population flows drive the expansion and contraction of the evolving hierarchal urban system. These spatial interactions matter for understanding whether an area's rate of growth is diverging from its historical average (Ioannides and Overman, 2004), both for cities and for rural areas. The dynamics of these population changes are of interest to not only academics, but also policymakers charged with predicting and managing these flows, especially when attempting to reverse population outflows or stagnation.

Interest in the spatial dimension of population growth dynamics among mainstream economists has burgeoned with the advent of the New Economic Geography (NEG) (e.g., Krugman, 1991). A long-time workhorse of economic geography has been the urban hierarchy lattice expressed in Central Place Theory (CPT) (Christaller, 1933). In CPT, lower-tiered places are dependent on higher-tiered places for access to successively higher ordered goods and services that are progressively offered at each higher tier. Extending CPT, the NEG formalizes the role of agglomeration effects in the dynamic formation of an urban system. A prominent feature of both NEG and CPT is the emergence of a hierarchy of cities based on regional market potential, featuring a symbiotic relationship among tiers, and between tiers and the rural fringe. Indeed, the hinterlands represent a source of agricultural products for urban markets and a market for manufactured urban products (Fujita et al., 1999).

Explaining the emergence of the American urban system through the early 20th Century was one of the key goals in the development of the theoretical NEG literature. Its chief predictions have generally been accurate. Yet, despite these successes, Eeckhout (2004) argues that there is a need for a better empirical understanding of how agglomeration economies influence *current* population mobility, including interactions with local industry compositions. For example, as a result of declining costs of transporting goods, relative to the cost of moving people, NEG models may be less accurate for predicting U.S. regional population growth in the 21st century (Glaeser and Kohlhase, 2004).

Related empirical research on the spatial distribution of cities has followed three streams. First are simulation exercises designed to explain the evolution of the urban hierarchy and the emergence of cities (e.g., Fujita and Mori, 1996, 1997; Fujita et al., 1999).[1] Second are studies that explore the empirical regularities of the urban system such as Zipf's Law and the rank order of cities (Black and Henderson, 2003; Gabaix, 1999; Ioannides and Overman, 2003; Eeckhout, 2004). Third, and most important for our study, is the empirical work that directly examines the spatial interaction among cities relating to their geographic distance, population, or place in the urban hierarchy (Hanson, 1998b; Dobkins and Ioannides, 2001, Ioannides and Overman, 2004). It is surprising how few studies directly examine the spatial interaction of places in determining current growth, given its importance in the theoretical underpinnings of the NEG, and related agglomeration models. One possible explanation for the paucity of empirical studies is the immense spatial data requirements (Hanson, 2001).

Despite the above research, there are major gaps in our understanding of spatial interactions within the urban system. For example, most related research is limited to larger urban centers and metropolitan areas. Since the theoretical importance of the hinterlands and smaller urban centers is fundamental in sustaining the urban hierarchy in the NEG, it is ironic that virtually none of the empirical work considers how lower-tiered places and rural areas currently interact with higher-level centers. Continued policy interest in regional economic development also makes it paramount that we understand the applicability of the theoretical NEG models for lower-tier and rural places, in the mature urban system.

Most NEG (and traditional CPT) models imply that a community's distance from (other) urban centers reduces spatial competition—i.e., population growth is positively related to distance from (other) urban centers. However, this inference is based on the assumption of a localized rural-urban trading pattern that involves the exchange of (rural) primary-sector products for (urban) manufactured ones. While historically reasonable as an explanation for the development of the American urban system, it may no longer adequately characterize the spatial interactions. Technological changes have greatly reduced the size of the primary and manufacturing sectors, with services gaining prominence (Quigley, 2002). In addition, both primary and manufactured goods are now traded on national and global markets.

[1] Another empirical line of research investigates other dimensions of agglomeration economies such as the size and geographical extent of knowledge spillovers and labor-market pooling (Rosenthal and Strange, 2001, 2003, 2005). However, Head and Mayer (2003) note that these other facets of agglomeration economies tend to fall outside the traditional domain of the NEG. Rather, NEG models tend to incorporate transportation costs, input-output linkages, and market potential effects that often produce urban growth shadows.

The relationship between lower- and higher-tiered places is increasingly comprised of commuting to (urban) jobs, populations in lower-tiered places accessing higher-ordered urban services and amenities, and urban sprawl and related centrifugal forces that are pushing residences further into rural exurbia. With better transportation and communication technologies, urban input-output linkages may have a more extensive spatial linkage than typically presumed in the NEG literature. Agglomeration economies may have a greater geographic scope than usually assumed by economists, with cities being an economic driver far beyond their borders (Partridge et al., forthcoming a). Thus, it is an empirical question as to whether modern relationships transcend the agglomeration shadows that are featured in the NEG and CPT literatures.

In summary, by examining only cities or metropolitan areas, past empirical research does not reveal the full dynamics and geographical interactions within the urban hierarchy, and leaves large holes in the populated landscape. Moreover, by not considering distance to *all* of the nearest higher-tiered urban centers, much of the spatial richness and heterogeneity that underlies the urban system has not been directly considered.[2] Thus, NEG outcomes such as agglomeration shadows or the distance-protection effects from large urban markets have not been not fully appraised.

This study attempts to fill this void by using U.S. county level data, which allows us to consider interactions of places from the lowest to the highest-tiered urban centers. While focussing on 1990-2000 county-level population growth, we include some assessment of 1980-2000 growth. As an alternative to NEG models, we model population change in a broad regional context. Our departing point follows from the Lucas and Rossi-Hansberg (2002) model of city development, though we allow for commuting and input-output externalities outside of the "city" border.[3] In their model, businesses weigh the favorable externalities derived from spatially concentrating to achieve closer input-output linkages versus gains from dispersing into residential areas to reduce commuting costs for their workforce. If we allow for commuting, or input-output linkages, to extend beyond the city border, nearby population growth will be

[2]One exception is Dobkins and Ioannides' (2001) innovative study of the dynamics of the 20th Century urban system. Even in this case, they examined only metropolitan areas and their only proximity measure was distance to the nearest higher-order city in the urban system (also see Ioannides and Overman, 2004). Besides omitting the hinterlands, another weakness would be that if they were considering a lower-tier metropolitan area, they did not consider distance to higher-level urban centers beyond the next-highest tier. Yet, these studies were more focused on the long-run changes in the U.S. urban system over the 20th Century and were less interested in smaller places.

[3]Though originally directed at understanding an individual city's development, the Lucus Rossi-Hansberg model is quite flexible, as Rossi-Hansberg (2005) shows in augmenting the model to examine international trade.

inversely related to distance from the urban center rather than directly (growth shadows) as predicted by most NEG models.

Our empirical assessment utilizes an extensive geographic information system database to examine the spatial dimensions of modern U.S. population growth in the urban hierarchy. Our primary contribution is to empirically sort out the relative roles of NEG versus competing explanations in assessing population growth in a *mature* urban system. In particular, we focus on how an individual county's geographic location in the urban hierarchy affects its growth—i.e., we consider distance to small urban centers all the way up to major-region/national centers. Thus, we are able to appraise whether there are "incremental penalties" or benefits for counties attributable to increasing distances to successively higher-tiered urban centers.

We examine whether close urban neighbors provide beneficial access to agglomeration effects, or produce an urban growth shadow as predicted in most NEG, or CPT, formulations. Next we evaluate whether other sources of agglomeration effects, including labor-market considerations, offer a better explanation. In our analysis, we take advantage of the recent delineation of micropolitan areas to include centers with as small as 10,000-50,000 population. Competing explanations of population growth are represented by factors such as amenities and industry composition. We conclude that some elements of NEG models are still valuable in explaining the evolution of a *mature* urban system, but that other models are also needed, especially in describing how large urban centers interact with the hinterlands and small urban centers.

In what follows, section 2 presents a theoretical model of population movements. This is followed by section 3's description of the empirical model and section 4's discussion of the results. Along with concluding thoughts, section 5 describes the implications for place-based policies.

2. Theoretical Considerations: Spatial Interactions and Population Dynamics

The distribution of economic activity across the American landscape reflects a multitude of location optimizing decisions by firms and households. Theories regarding how optimizing behavior has led U.S. economic activity to concentrate, or agglomerate into core areas, need to be synthesized to inform our empirical model and to distinguish the key competitors from the NEG framework. That is, despite a similarity in their predictions (Brülhart, 1998), different underlying mechanisms for agglomeration produce different core-periphery relationships. And since the mechanisms underlying agglomeration economies are not static, changes in the underlying forces have implications for core-periphery dynamics.

According to neoclassical theory, an uneven spatial distribution of economic activity results from regional differences in geography, factor endowments, and technology. Yet product and factor market competition limit the degree of economic concentration in regions with natural advantages. Increasing concentration in many areas, and development of core areas without natural advantages (Krugman, 1993), require other explanations.

New economic geography models incorporate imperfect competition, increasing returns to scale, and mobile factors, making the concentration of economic activity completely endogenous.[4] Yet, NEG models focus primarily on pecuniary externalities, ignoring other factors such as regional labor market considerations of commuting and supply-side migration innovations. In NEG models, labor resides in the region of employment and migration responds solely to labor demand. Thus, NEG models do not utilize the richness and diversity of considerations underlying location decisions, particularly for households. This may reduce the relevance of NEG models for explaining regional growth patterns in the 21st century in which household location considerations are becoming paramount (Glaeser and Kohlhase, 2004).

Below we discuss competing theories and various mechanisms for agglomeration of economic activity. To provide the basis for empirical testing, we emphasize the predictions of NEG models, and also highlight insights from competing explanations for how geographic distance from core economic areas affects current growth dynamics of peripheral regional economies.

New Economic Geography Core-Periphery Dynamics

In NEG models, with their focus on pecuniary effects, close proximity to suppliers of intermediate inputs and customers lowers firm transportation costs (Venables, 1996), in which scale economies may exist in the production of non-traded intermediate inputs (Fujita, 1988). However, increased competition associated with close proximity of economic activity acts as a dispersal force (Krugman, 1991; Combes, 2000), limiting agglomeration.[5] Firms in the areas closest to agglomeration centers find themselves in

[4] New trade theory models likewise assume imperfect competition and increasing returns to scale. But they assume exogenously given differences in market sizes and geographically immobile labor (Brülhart, 1998). Thus, they cannot explain the concentration of economic activity in areas without natural advantages, and are unsuitable for analysis of regional economies with highly mobile labor such as in the United States.

[5] Product differentiation can nevertheless weaken price competition associated with economically dense areas.

what is referred to as "Krugman's agglomeration shadow" (Dobkins and Ioannides, 2001, Ioannides and Overman, 2004), in which they are able to produce only the most basic goods and services for which there is less competition. Small cities may thus serve only a local population, while larger cities serve wider geographic markets that include small cities (Krugman, 1996), leading to an urban hierarchy consistent with CPT (Fujita and Thisse, 1996).

In a dynamic growth sense, NEG models also suggest that population in the most distant hinterlands would expand to provide the urban center with agricultural products, until densities are sufficient for a new urban center to emerge (Fujita et al., 1999). This pattern is consistent with the positive distance-population growth linkage suggested by agglomeration shadows. In a mature urban system, the hinterlands would be approximately uniformly settled (as in CPT), which would leave growth shadow effects as the dominant NEG mechanism for a distance-population growth relationship.

In Krugman's (NEG) models (1991; 1993), labor also plays a role in agglomeration, responding to higher real wages associated with a diversity of manufactured consumer goods, which facilitates the concentration of firms through easing factor competition. Additional labor also represents an increase in demand that reinforces agglomeration (Puga, 1999). Although household migration imparts its own competition effects, these are likely to be of secondary importance (Combes and Overman, 2003).

In the modern era, agglomeration patterns can change with lower transportation costs, improved communication technology, shifts in trade patterns, and industry structural change. Industrial restructuring away from goods to services could induce major changes in an urban system that developed based on 19th and early 20th century parameters. Falling transportation costs can have an ambiguous effect on agglomeration. To the extent agricultural goods become cheaper to ship into core urban areas, the tendency towards agglomeration increases (Fujita and Thisse, 1996). Yet falling transportation costs can also disperse manufacturing activity to less congested areas (Desmet and Fafchamps, 2005), as they may weaken agglomerative upstream and downstream linkages (Black and Henderson, 1999). Shifting international trade patterns can cause economic activity to move away from historic urban centers to border areas to reduce associated transportation costs (Hanson, 1997). Yet empirical evidence suggests a strong lock-in effect at the top of the urban system, with more churning at lower levels.[6] Therefore,

[6]Some NEG theories suggest catastrophic shocks could generate entire realignments of the urban system (Fujita

because the existing urban system has evolved from a different set of parameters than currently exists, the current parameters could produce a vastly different pattern of spatial interaction.

Moving Beyond the NEG Framework

Explaining modern day core-periphery population dynamics requires extending the NEG framework to accommodate forces that may change the nature of the predicted spatial relationships. In contrast to Krugman's NEG agglomeration shadow, current economic realities generally predict a positive relationship between population growth and close proximity to the largest agglomeration centers.

In their model of metropolitan firm location, Lucas and Rossi-Hansberg (2002) postulate that firms weigh the benefits derived from spatially concentrating to achieve closer input-output linkages against the gains of dispersing into residential areas to reduce commuting costs for their workforce. These models would yield more extensive spatial interactions when allowing commuting and input-output externalities to extend beyond their border (in which both commuting costs rise and externalities decay over distance). Thus, over the area where commuting or input-output linkages extend beyond the city border, population growth would be *inversely* related to distance from the urban center rather than *directly* related as predicted by NEG models. Besides transport costs, transactions costs associated with trading with firms in remote areas, such as information costs about demand conditions and locating trusted suppliers (Hanson, 1998a), also increase with distance from the core.[7] Other congestion costs associated with increased size of the largest agglomeration centers also may cause positive spillovers to nearby areas. Such costs may arise from higher crime, pollution, and land prices (Glaeser, 1997; Ottaviano and Puga, 1998).

In extending the Lucas and Rossi-Hansberg model through introducing a broader geographic scope for commuting and input-output externalities, our approach alters predicted spatial interactions in the urban system. In addition, to account for spatial interactions, interregional migration must be explicitly included. Interregional migration is not germane in the Lucas and Rossi-Hansberg city-development model and it plays a very passive role in NEG models.[8] Thus, we need a broader framework that includes

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and Mori, 1997). However, Fujita and Mori (1996) show how natural advantages such as a port can lead to a lock-in effect where the city thrives due to initial advantage. Black and Henderson (1999, 2003) provide empirical evidence that at least larger cities are locked-in to their higher status for centuries at a time, though there is more churning among lower-tiered cities. Likewise, Davis and Weinstein (2002) show that even the ruinous Allied bombing campaigns against Japan during World War II did not significantly alter its urban system in the long term.

[7]For example, Wolf (1997) reports that U.S. domestic goods are shipped an average of 255 miles, in which distances were substantially shorter for intermediate goods relative to consumer goods.

[8]NEG models regularly focus on firm movements (Krugman, 1991). Specifically, firms maximize profits which

population migration.

In our framework, a representative household locates to maximize utility in the consumption of amenities (AMENITY), traded goods (X), and housing (H):

(1) $U_i = U_i(AMENITY_i, AMENITY_{ij}, X_i, H_i)$,

where i denotes region of residence, and j indicates the collective of proximate outside regions. Utility is positively related to amenities in the region, as well as a vector of amenities accessible in nearby regions. Urban household amenities include diverse consumption opportunities such as unique services available only in the higher-tiered urban areas, and a more active social environment.[9] However, access to amenities outside the region is costly, increasing in terms of a vector of distances (d_{ij}) between region *i* and the other regions. Labor income influences the amount of goods, services, and housing which households can purchase. The region's wage rate (w), and the wage rate in regions within commuting distance, multiplied by the corresponding probabilities of employment (er), determines expected labor income. Commuting is costly, increasing with distance from the region where jobs are located. The diversity of employment opportunities provided by a large urban center also reduces the risk of unemployment (1-er), which can extend over a wide geographic range (Rosenthal and Strange, 2001). Consumption is constrained by the prices of traded goods (p), normalized to equal the national price, prices of locally produced goods and services (pc), and the price of housing (ph).

Therefore, the corresponding indirect utility function can be written as:

(2) $V_i = V_i(AMENITY_i, AMENITY_{ij}, p, pc_i, ph_i, er_i w_i, er_{ij} w_{ij}, d_{ij})$,

in which utility is higher where there are greater economic opportunities and more possibilities for consuming amenities. However, distance between regions reduces the potential gains of consuming amenities and earning labor income in other regions.

Interregional equilibrium requires equalized utility across space. Yet information constraints and moving costs mean that migration only partially adjusts in a given period to utility differentials. Thus, net migration (NM) into region *i* in a representative period relates to the difference in regional household utility from the rest of the U.S. (V_{ROUS}):

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are usually positively related to agglomeration economies, but inversely related to congestion costs. Firms move to locations with higher expected profits until profits are equalized in core and hinterland locations.

[9] These demands may increase over time with rising national income (Glaeser, 1997).

(3) $NM_i = \alpha_i(V_i - V_{ROUS}),\ 0 \leq \alpha_i \leq 1,$

where α is the rate of adjustment.

Synthesis of NEG and Extensions for Core-Periphery Population Dynamics

The predicted population dynamics of NEG models are altered when considering the extensions discussed above. Consistent with CPT, the NEG predicts a hierarchy of cities, in which the availability of services increases when moving towards the top of the hierarchy. This occurs because of increasingly onerous demand thresholds for higher order services and spatial competition among firms, the latter acting as a nearby dispersal force.

Each tier city has services that are available in lower tier cities plus some additional services. For example, suppose there are n tiers in the hierarchy. The top tier (n) has the full range of services including the highest-order consulting, financial, and legal services. At the first or lowest tier, available services are only the most basic such as convenience stores. Residents and businesses in the first tier must travel to the nearest cities to obtain the second, third, and higher orders of services, etc.

In NEG models this hierarchy is usually associated with agglomeration growth shadows, where spatial competition near higher-tiered centers limits the growth of local businesses. Yet, because of a number of the extensions discussed above, spatial competition shadow effects may be overcome. Rural areas and smaller urban centers will benefit from close proximity to successively higher-tiered centers, while incurring a penalty for increasing remoteness. The penalty increases for having to travel incrementally farther to access increasingly higher-orders of services, to access employment through commuting to 'thicker' labor markets, and to access higher-ordered urban amenities.

In reaching the *nth* tier, the successive incremental distance penalties for a community *k* in tier *j* can be denoted by the following, where j falls between 1 and *n-1*. First, for community *k*, let the incremental distance to a higher-tiered place with at least the *mth* order of "services" equal d_k^m where *m* falls between *j+1* and *n*. Also, assume the marginal penalty of greater incremental distance from a place with at least the *mth* order of services is equal to φ^m. Thus, the sum of the accessibility penalties for a given community *k* in the *j*th tier can be depicted as:

(4) $$Penalty_{jk} = \sum_{i=j}^{n-1} d_k^{i+1} \varphi^{i+1} .$$

Equation (4) yields the total distance penalty across the urban hierarchy for community *k*. When other non-NEG factors are considered, the penalty consistently increases as we move away from the *nth* tier, or any higher-tiered areas. Yet, the "penalty" could be negative (i.e., be a benefit) if NEG growth shadows dominate, which forms one key empirical question.

3. Empirical Implementation

The underlying agglomeration mechanisms discussed above vary in their predictions regarding the effect of distances from agglomerated core areas on economic performance in peripheral areas. Our primary interest is how a place's geographic position in relation to its nearest cities in the urban hierarchy affects its growth process—especially the little-studied rural hinterlands and small urban centers whose markets underlie the evolution of cities in CPT and the NEG. We examine population growth rather than income growth because regional mobility of households and firms causes population (and employment) to better reflect regional welfare (Glaeser et al., 1992; Glaeser et al., 1995). For example, higher wage rates may be a signal of more household disamenities rather than increased welfare (Beeson et al., 2001).

We regress population growth between periods 0 and t on initial period geographic and socioeconomic conditions at time 0. This approach allows for sluggish transitions to a long-run equilibrium in which shocks to a local economy set off an adjustment process. The specification is consistent with related literature that utilizes a cross-sectional reduced-form approach incorporating geographic and related factors that affect population movement (Hanson, 1998a; Eeckhout, 2004; Partridge et al., forthcoming a).[10] Specifying subsequent population growth as a function of the initial-period characteristics has another advantage in that the predetermined nature of many of the explanatory variables should help mitigate concerns with statistical endogeneity. Sufficient statistical endogeneity may bias the results, which is a topic we return to below.

In implementing the model, population change is examined primarily over the 1990-2000 period, along with more limited analysis for the 1980 to 2000 period to assess robustness of the results. The time

[10]Examining growth rates also has the advantage of differencing out any fixed effects associated with levels or the scale of the locality (Hanson, 2001). A full-scale fixed effect approach is inappropriate. First, because a county's distance to the urban centroid is constant over time, the key distance measures could not be included as variables. Second, because local population growth and its underlying determinants are often persistent, a fixed effects (or first difference) approach would difference out these cross-sectional effects, subsuming them into the local-area's fixed effect. The regression coefficients for the other explanatory variables would not capture the long-run effects we desire (Partridge et al., forthcoming b).

periods coincide with the 1980, 1990, and 2000 Censuses. Counties in the lower 48 states and the District of Columbia are our units of observation. Counties have the advantage of being defined for the entire continuum from very rural to extremely urban.[11] Unlike cities or metropolitan areas, county-level analysis does not suffer from selectivity bias in that counties that never "succeeded" in terms of becoming urban centers are still included in the sample. Counties also have the advantage that their borders are not affected by their recent growth experience (such as metropolitan areas) (Hanson, 1998a).

We subdivide the sample into multiple sub-samples to examine the different transmission mechanisms across the central-place hierarchy. To help capture the role of small urban centers in the hierarchy, we take advantage of the recent delineation of micropolitan areas, which include counties with tight commuting linkages to a smaller "urban" center of 10,000–50,000 people. The 10,000 people minimum-size distinction for a city anchoring a micropolitan area was developed after lengthy study by the Census Bureau—i.e., these cities were deemed the smallest grouping to have developed surrounding regional labor markets.[12]

We refer to counties that are not a part of either a micropolitan area or a larger metropolitan area as rural/hinterlands, which sit in the lowest place in the urban hierarchy. Micropolitan areas are treated as the next higher group in the hierarchy. We expect different transmission mechanism for these two groups. For rural counties, CPT and NEG suggest that more remote counties may fare better due to some distance protection from spatial competition. However, greater distance from the nearest urban center may limit growth due to reduced commuting opportunities, weaker trade linkages, fewer spillovers arising through personal contact, and greater distance to urban consumption amenities. Peripheral counties *within* metropolitan or micropolitan areas could grow faster due to urban sprawl and suburbanization.

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[11]Following the U.S. Bureau of Economic Analysis, there are cases where independent cities are merged with the surrounding county to form a more functional economic area (especially in Virginia). Forty three mostly small rural counties are also omitted due to the lack of economic data. For details of sample construction, see Partridge and Rickman (forthcoming).

[12]A micropolitan area is approximately the county/counties that contain a city of between 10,000-50,000 and other counties with tight commuting links. A metropolitan area is approximately the county/counties that contain a city of at least 50,000 and other counties with tight commuting links. Most of the time, we use the 2003 metro/micropolitan area definitions, which allows us to use micropolitan areas (which were first defined in 2003) and to include counties in the metro sample if they had emerging commuting linkages. We desire an expansive definition of MAs to isolate *within* MA growth due to changing commuting patterns versus *intra* urban center interactions due other factors. However, we do sensitivity analysis that uses the earlier 1999 definitions that mostly use 1980s commuting patterns to establish boundaries for the then existing (1990) metropolitan areas along with any new metropolitan areas that were defined during the 1990s. For details, see the Census Bureau MA and Micropolitan definitions at http://www.census.gov/population/www/estimates/metrodef.html (on Dec. 15, 2005).

Moving up the urban hierarchy, it is possible that some metropolitan areas may benefit from closer proximity to a larger urban center due to enhanced agglomeration economies and decentralization of the larger center (Dobkins and Ioannides, 2001). However, NEG theory generally suggests that larger urban centers likely need some distance protection from the highest-order centers to reduce spatial competition (Fujita et al., 1999). Thus, to fully explore differences across urban tiers, we divide the metropolitan area sample into counties surrounding a metropolitan area of less than 250,000 people and more than 250,000 people. The 250,000 division point seems reasonable in terms of size and it splits the metro sample into about one-half, though we conduct sensitivity analysis using different break points.

For each sample, the dependent variable is the percent change in county population between periods 0 and *t.* The most complete reduced-form specification for a given county *i*, located in state *s* is represented as:

(5) $\%\Delta POP_{is(t\text{-}0)} = \alpha + \delta\ POPDEN_{is0} + \boldsymbol{\varphi}\ \mathbf{GEOG}_{is0} + \theta\ \mathbf{DEMOG}_{is0} + \boldsymbol{\psi}\mathbf{ECON}_{is0} + \boldsymbol{\gamma}\mathbf{AMENITY}_{is0} + \sigma_s + \varepsilon_{is(t\text{-}0)}$,

where *POPDEN* is initial-period population density to control for own-county agglomeration or congestion effects. **GEOG**, **DEMOG**, **ECON**, and **AMENITY** are vectors that represent geographic attributes such as distance to different tiers in the urban hierarchy; demographic characteristics; economic characteristics; and amenities. The regression coefficients are α, δ, $\boldsymbol{\varphi}$, $\boldsymbol{\theta}$, $\boldsymbol{\psi}$, and $\boldsymbol{\gamma}$; σ_s are state fixed effects that account for common factors within a state; and ε is the residual.

In our analysis, we begin with much more parsimonious models than equation (5) to assess whether potential multicollinearity and endogeneity are affecting the key results. The county residual is assumed to be spatially correlated with neighboring counties in which the strength of the correlation is inversely related to the distance between the two counties. We use a generalized method of moments (GMM) procedure to produce t-statistics that are robust to cross-sectional spillovers (Conley, 1999).[13] Appendix Table 1 presents the detailed variable definitions, sources, and descriptive statistics.

The **GEOG** vector contains several spatial measures that reflect proximity to urban areas higher in the hierarchy. An urban center is defined as a metropolitan area (MA) or micropolitan area (MICRO). Thus, the

[13]The bandwidth extends 200kms, after which we assume no correlation in county residuals. We also calculated robust t-statistics using the Stata Cluster command, in which we assumed that the residuals are correlated within a given region, but uncorrelated across regions. For the urban sample, the economic regions we used were the MICRO or MA counties. For the "rural" sample, the regions were the 177 Bureau of Economic Analysis economic regions that are constructed to be functional economic areas. The clustered t-statistics produced estimates that were almost identical to the GMM t-statistics, suggesting that spatial error dependence mostly occurs within given regions.

first measure is distance to the nearest urban center of any size. This is the distance from the center of the county to the center of the urban area if it is part of a multi-county MA or MICRO. If the county is not part of a MA or MICRO, it is the distance from its center to the center of the nearest urban center .[14]

To reflect additional "penalties" for counties whose nearest urban center is not the highest level in the urban hierarchy, we include the incremental distance to more populous higher-tiered urban centers. First, we include the incremental distance in kilometers from the county to reach an MA.[15] We also include other variables that measure the incremental distance to reach an urban center of at least 250,000, at least 500,000, and at least 1.5 million population.[16] The incremental distances again reflect the additional penalty (or benefit) a resident/business of a county faces because they have to travel a further distance to access progressively higher-ordered urban centers. Fully accounting for these attenuation effects would greatly extend knowledge of the full spatial interactions within an *existing* urban hierarchy.

Our choice of population thresholds for the distance measures roughly correspond to Overman and Ioannides (2001). The largest category approximately reflects national and top-tier regional centers, the over 500,000 plus category corresponds to the sub-regional tiers, while the other smaller-center sizes capture different-size labor markets (for commuting) and access to personal and business services.

Other variables in the **GEOG** vector include population of the nearest or actual urban center (MICRO or MA) to the county. A larger nearest/actual urban center could produce greater population gains if agglomeration economies, including the effects of larger labor markets for commuting and proximity to higher-order services and amenities. Yet, congestion effects produce an offsetting response to a greater

[14]We obtained the population weighted centroid of each county from the U.S. Census Bureau. We then calculate a population weighted centroid of each micro/metropolitan area. The population category for MAs is based on their initial year population—i.e., 1980 or 1990. That is, a given MA area's distance and population categories can change depending on whether the initial period is 1980 or 1990.

[15]For example, if rural county A is 40kms from a micropolitan area and is 70kms from the nearest metropolitan area, the incremental distance to the nearest MA would be 30kms. Conversely assume county B is located in a MICRO, being 25kms from the center of its micropolitan area and 70kms from the nearest MA. Then the corresponding incremental value to the nearest MA would be 45kms (70-25). For a county already located in a MA, the incremental value is zero because it already is a MA.

[16]Incremental distance is calculated as before. If the county is already nearest to a MA that is either larger than the size classification or in the size classification, then the incremental value is zero. For example, if the county's nearest urban center of any size (or MA of any size) is already over 500,000, then the incremental values for the at least 250,000 and at least 500,000 categories are both equal to zero. To take another example, if say rural county A is 30kms from a micropolitan area (its nearest urban center), 70kms from its nearest MA of any size (say 150,000 population), 120kms from a MA >250,000 people (say 400,000 population), 160kms from a MA >500,000 (which happens to be 2 million). Then the incremental distances are 30kms to the nearest urban center, 40 incremental kms to the nearest MA (70-30), 50 incremental kms to a MA >250,000 (120-70), 40 incremental kms to a MA >500,000 (160-120), and 0 incremental kms to a MA >1.5million (160-160).

nearby population, which also apply if greater urban population creates a growth shadow.

In this manner, analogous to the distance variables, we include incremental population variables for the added population of the nearest MA, a MA of at least 250,000, a MA of at least 500,000; and a MA of at least 1.5 million (see note 17).[17] These variables measure any incremental "cost" or "benefit" in terms of population growth if its closest urban areas are incrementally larger cities. For example, beyond the effects of the nearest urban center, a county may benefit from additional agglomeration economies if its second closest urban center is larger.

To be sure, because we already include incremental *distance* to urban centers within various tiers, these population terms account for any *marginal* population impact. That is, the incremental population variables account for *within* urban tier effects of having larger urban centers, in which the incremental distance terms account for the penalties of reaching an urban center of at least the specified size.[18] As described below, we also tried other specifications using the actual population rather than the incremental population, as well as models that omitted the incremental population all together, but there was almost no change in the key incremental distance results.

In some models, we control for population in surrounding counties within the county's BEA economic region net of the county population (see footnote 17 and the Appendix for details). This variable accounts for many factors such as agglomeration spillovers and CPT/market potential effects (Hanson, 1998a; Black and Henderson, 2003; Head and Mayer, 2003). Note that empirical NEG studies typically consider market potential measures without usually exploring whether the measured "market potential" population is located in "large" urban centers or is dispersed in many towns and smaller urban centers. By contrast, we not only examine market potential, but also the county's proximity to various urban centers in the urban hierarchy.

The remaining control variables account for other potential causes of population change aside from geographic location. They are mainly included as tests of robustness for omitted variables. First, we account for natural **AMENITIES** measured by climate, topography, percent water area, and a related amenity scale

[17]For example, if the nearest/actual urban center is 45,000 people (micropolitan area), the next closest urban center is 600,000 population, the third closest urban center is 2million people, then the incremental population of nearest metropolitan area is 555,000, the incremental population of a MA that is >250,000 is 0, the incremental population of a MA >500,000 is 0, and the incremental population of a metropolitan area that is at least 1.5 million is 1.4million (i.e., 2million minus 600,000).

[18]For example, take the 250,000 cutoff, the incremental distance to an urban center variable accounts for penalties to reach an urban center of at least 250,000 population. The incremental population variable accounts for any marginal spillovers due to the relevant urban center having a population above the 250,000 cutoff.

constructed by U.S. Department of Agriculture (see Appendix). Pleasant climate and beautiful landscapes have long attracted migrants (Beeson et al., 2001). The **AMENITIES** vector is included in all models as it reflects a natural location advantage that is independent with the urban hierarchal effects that are of interest.

Second, we control for state fixed effects in some models to account for state-specific factors including policy differences, geographic location with respect to coasts, and settlement period.[19] When state fixed effects are included in the model, the other regression coefficients are interpreted as the response after a *within* state change in the explanatory variables. However, one concern with including state fixed effects is that any common effects within a given state (e.g., high population density) are swept into its fixed effect, or the state indicators may "steal" some of the direct **GEOG** distance and population effects.

To account for human capital migration effects and initial human capital spillovers, in some models we include initial-period **DEMOG** measures of racial composition, past immigration, age and educational attainment, which follow from past studies of population growth (e.g., Glaeser et al., 1995). To control for disequilibrium economic migration, some models incorporate the following **ECON** measures: initial 1989 median household income, initial 1990 unemployment rate, 1990 employment shares in agriculture and in goods production. We also control for the 1990-2000 industry mix employment growth, which is a common exogenous measure of demand shifts.[20] Industry-mix employment growth proxies for local job growth, which affects migration and commuting patterns. To account for nearby county economic spillovers, some models include BEA-region values of median income, unemployment, and industry-mix growth measures, excluding the county of interest from the regional calculation (see the Appendix).

4. Empirical Results.

Descriptive statistics are reported in Appendix Table 1 for the full sample and in Appendix Table 2 for selected sub-sample statistics. Table 1 contains the results for counties located in core rural areas, MICRO areas, small MAs with less than 250,000 population, and large MAs with population over 250,000, all using 2003 definitions. Sensitivity analysis that uses 1999 metropolitan definitions is described below.

[19]We experimented with also including three indicators for close proximity (adjacent or within 50kms) to the Atlantic Ocean, Pacific Ocean, and the Great Lakes. However, our results were essentially unaffected and the ocean/lake proximity variables were generally insignificant. Thus, we omitted these measures from our analysis assuming that state fixed effects sufficiently pick up any of these initial/natural advantage effects.

[20]Industry mix employment growth is the sum of the county's initial industry employment shares multiplied by the corresponding national industry growth rates over the subsequent period. Because national industry growth should be exogenous to industry growth in a given county, it is routinely used as an instrument for local employment growth and local demand shifts (Blanchard and Katz, 1992; Simon, 2004).

4.1 Base Regression Models

With the exception of the over 250,000 MA group, for each sample, we start with a very parsimonious model that only includes the distance and amenity measures, followed by a second model that adds the urban population, economic, and demographic variables, and a third model that adds state fixed effects. These models successively test the robustness of the results to alternative economic explanations for population change such as initial economic conditions, or to econometric concerns such as omitted variables and multicollinearity. In Table 1, when comparing the key distance results across columns (1)-(3) for rural counties, columns (4)-(6) for MICRO counties, and columns (7)-(9) for small MA counties, they are very similar.[21] This robustness, though a good feature, is somewhat surprising as it might be expected that controlling for added variables may mask some of the key agglomeration or attenuation findings. Thus, we can be more assured that the results are not artifacts of omitted variables or multicollinearity.

Given the robustness of the results, we describe the results of the more fully specified models in columns (3), (6), (9), and (10). First, we start with the core rural results, which are of particular interest given the lack of knowledge on how the hinterlands interact in the existing American urban system. We then examine the smaller urban center results followed by the largest MA results. We focus our discussion on incremental distance results due to their first-order importance.

Urban-Hinterland Interactions

The distance to the nearest urban center coefficient indicates that for every kilometer further that a rural county is from its nearest urban center (of any size), it grew about -0.1% less over the 1990s. When measured at the mean distance of 60kms (Appendix Table 2), this translates into 6.1% less population growth compared to a rural county adjacent to the urban center's core. The influence of the urban hierarchy does not end there. If the nearest urban center is only a MICRO area, the rural county loses an additional 0.038% of population per incremental km to reach a MA of any size. Likewise, if the second closest urban center is only a MA of less than 250,000 people, there is another penalty of 0.03% per incremental km to reach an urban center of at least 250,000. Finally, there are corresponding population growth penalties of about -0.02% and -0.01% per km to reach MAs of at least 500,000 and 1.5 million. Using the mean

[21] Some of the incremental population variables became statistically insignificant when controlling for state fixed effects, suggesting that common state-specific effects are correlated with population. The greater than 250,000 MA sample results are also robust to the same specification changes, but we do not report those results due to brevity.

incremental distances (Appendix Table 2), for the typical rural county, the total penalties if the nearest urban center has less than 1.5 million people sum to 11.8% less population growth during the 1990s.[22]

Although it is notable that there are incremental penalties for a hinterland county not having access to urban centers as large as 1.5 million, the largest marginal penalty is for accessibility to any urban center as small as 10,000. We believe this indicates that accessibility for commuting and basic urban input-output externalities as being a first-order factor for hinterland growth, with higher-tiered effects being secondary. Nonetheless, these results are inconsistent with an urban growth shadow extending to nearby rural areas.

The population loss for more remote rural counties suggests that the current urban system is not in long-run equilibrium, and rural/hinterland communities are still experiencing persistent population losses to larger urban areas with more agglomeration economies. This pattern is consistent with ongoing restructuring of rural primary-sector firms. The lack of accessibility to higher-ordered urban inputs and amenities may exacerbate problems for remote rural counties.

Small Urban Center Spatial Interactions

Regarding small urban centers, the MICRO and small MA results in columns (6) and (9) reveal that more distant counties *within* an urban center are growing faster, consistent with sprawl and suburbanization (though the small MA result is only marginally significant). For MICRO areas, the incremental distance to the nearest MA coefficient implies a 0.025% population penalty per every km further away. Beyond that, only the incremental distance to an urban center of at least 250,000 has a statistically significant adverse impact on MICRO county population growth.

For the small MAs, the point estimates suggest that for increased incremental distance from urban centers greater than 250,000, 500,000, and 1.5 million, small MAs are marginally penalized even more than rural counties for being further away from higher-tiered metropolitan areas. For example, a one standard deviation increase in incremental distance from the three larger MAs categories (Appendix 2) produces an expected population loss of 9.6% for small MAs. This penalty is likely related to a loss of access to higher order services and amenities, though an urban amenity effect is likely a stronger factor for rural households. Conversely, it is unlikely this penalty is attributable to fewer commuting opportunities, because MAs are

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[22]Alternatively, a one standard deviation increase in the distance to the nearest urban center is associated with an expected 3.2% decline in rural county population growth, while a one-standard deviation increase in all of the incremental distance terms is associated with an expected decrease in population growth of 10.9%.

defined by the U.S. Census Bureau as being distinct labor markets, though this is considered more below.

As opposed to the distance variables, the urban center *population* variables tell a more ambiguous story. First, for the rural and small-urban center results in Table 1, county population growth is inversely related to its own initial population density, suggesting weak agglomeration/local-market potential effects. Yet an offsetting factor is that the population of the nearest or actual urban center is positive and statistically significant in the rural and small MA samples. Together, these results suggest that the effects of agglomeration and localized market potential are mixed at best for rural and small urban areas. Inconsistent with growth shadows, the incremental population variables are mostly insignificant. The exception is in the small MA sample where the incremental population of the nearest urban center over 250,000 population has a statistically significant positive impact, which suggests positive spillovers (not growth shadows). In a test of robustness, we replaced the incremental population variables with the actual urban center populations, but the results were quite similar to those reported (not shown).

Neighboring county population, which is a measure of possible agglomeration spillovers and market potential, is insignificant in the core rural and the two small urban center models. Regarding the rural results, this is inconsistent with CPT's assumption that rural areas market their products in the nearby region. It could be that smaller communities mostly sell their products very locally (e.g., a local grocery store) or export their (commodities) products on a national/international scale that is far beyond proximate markets. For MICRO and small MAs, this finding further indicates that agglomeration spillovers are weak and that (regional) market-potential effects are small. Together with the negative population density results, regional market-potential effects through forward linkages appear to be less important than accessibility related to commuting or availability of business and personal services (proxied with incremental distance).

Large Urban Center Spatial Interactions

Column (10) of Table 1 shows the corresponding results for the counties located in large MAs (i.e., population >250,000). With the exception of the positive *within* MA distance coefficient, none of the proximity variables are significant. The positive own-county population density variable suggests that there are favorable local agglomeration effects (at the 10% level), consistent with a size threshold where own agglomeration effects become more important for larger urban centers. The positive and significant (at the 10% level) neighboring-county population coefficient suggests that the agglomeration benefits are also derived regionally. There is some evidence of an adverse growth-shadow effect for counties located in MAs of between 250,000-1.5 million when they are close to an even larger urban center with population over 1.5 million.[23] Combined with the corresponding insignificant distance effect, it may be that only the very large higher-tier metropolitan areas cast a growth shadow. In sum, in the large MA model, NEG features such as market potential and growth shadows play more of a role. However, the corresponding insignificant incremental distance findings are most consistent with Ioannides and Overman's (2004) finding that there are no clear spatial interactions between neighboring cities. We qualify their conclusion by noting that the small interactions appear most applicable to larger MAs.

Further Search for Growth Shadows

To further search for the existence of growth shadows, we added interactions of the nearest/incremental-urban-center-distance with the corresponding urban center population (not shown). This tests whether growth shadow effects attenuate with distance. These interaction variables were jointly statistically insignificant in the MICRO and small MA models, but they were significant at the 5% level in the rural and large MA cases.

For rural counties, negative distance-population interaction coefficients generally suggested lower population growth the more distant the county was from an urban center of a given size. This is exactly the opposite of an agglomeration growth shadow. For the "smaller" large MAs with between 250,000 and 1.5 million population, a positive interaction coefficient suggested that being a greater distance from an urban center of at least 1.5 million mitigates the adverse population effects described above. This pattern would be expected if these large centers cast a growth shadow on their "smaller" large urban centers. However, because of the complexity of interpreting these results and because the other key results were generally unaffected, we do not further pursue the distance-population interactions.

4.2 Robustness Tests

Several models were estimated to test the robustness of the findings. First, column (1) of Appendix Table 3 reports the results of combining the core-rural and MICRO samples in a non-MA sample (using the

[23] In sensitivity analysis, we experimented with a 500,000 dividing point for "small" and "large" MAs. The key difference is the less than 500,000 category took on some characteristics of the current over 500,000 grouping. In particular, the incremental distance coefficients were both much smaller in magnitude and less statistically significant, consistent with the responses in the greater than 250,000 grouping. Thus, the 250,000 division point appears to denote some clear sample heterogeneity.

2003 definitions). These results fairly closely correspond to the core-rural results. Thus, dividing the nonmetropolitan sample into two components appears warranted as MICRO counties have their own dynamics that are masked in a combined nonmetro sample. Research that only considers a metro/nonmetro division would incorrectly conclude that these small urban centers more closely resemble core rural counties, though small urban centers of at least 10,000 people begin to resemble their larger urban counterparts. Appendix Table 3 also reports the results of using 1999 metropolitan boundaries to define our sample (MICRO areas were not defined in 1999). Nonetheless, the results are generally robust to changes in the MA boundaries, with the only notable change being that the incremental distances to an urban center of at least 500,000 and greater than 1.5 million are no longer statistically significant in the small MA model.[24]

Table 2 reports further sensitivity analysis using population change for 1980-2000 and related explanatory variables based on 1980 population.[25] The core-rural and small urban area patterns are almost identical to those in Table 1. One exception is that inconsistent with deconcentration/sprawl effects, outlying counties *within* a given MICRO or small MA grew at a slower rate than core counties during the longer period with state dummies included in the model, all else constant (though only the small MA coefficient was statistically significant). The large MA results were also similar between the two periods. Yet, there was a statistically significant inverse relationship between 1980-2000 population growth of an urban center of 250,000–500,000 people and its distance to an MA of at least 500,000 people, which is now inconsistent with an urban growth shadow.

4.3 Summary of Findings

To summarize our findings, we generally find that closer proximity to a higher-order urban center is positively related to population growth for counties in rural areas, MICRO areas, and small MAs. To some extent, this is inconsistent with CPT and related NEG models that hypothesize growth shadow effects where greater distance from a higher-order urban center would positively affect an area's population growth. In fact, our negative findings on CPT and NEG are even stronger than those reported in Dobkins and Ioannides (2001).

Unlike CPT or NEG growth shadow effects, these results also suggest that for smaller urban centers

[24]In defining the sample of small and large MAs, 1999 boundaries are used in determining whether the MA fit into its particular population category (e.g., less than or greater than 250,000).

[25]The demographic and economic variables are not included in this specification due to electronic data availability constraints.

and rural communities, population growth is favorably affected by being closely tied to larger urban centers. There is less evidence that (regional) market potential is a good explanation for rural and small urban center population change because the own population density and the neighboring county population coefficients are the wrong sign or insignificant. One reason for the mixed pattern could be "exports" from lower-ordered urban centers and the hinterlands are more directed to national and international markets than to regional markets.

For larger MAs, we found surprisingly little evidence that proximity to (even) higher-order urban centers affect their growth. The pattern is consistent with offsetting effects from decaying agglomeration effects (e.g., spillovers) and CPT factors. There is some evidence that among "medium" MAs of 250,000 to 1.5 million, there are adverse growth-shadow competition effects from being proximate to very large (national) urban centers. Nonetheless, the stronger pattern across all the MA groupings is that population growth is not greatly affected by the size of their nearest neighbors.

4.4 Commuting Linkages

The lack of urban growth shadows could relate to tight commuting linkages between cities, rather than input-output linkages, which may quickly attenuate outside of city boundaries as in most urban models of city development. To decompose the role of commuting linkages, from other linkages, we next consider the role of urban-center employment growth in affecting the spatial interactions.[26] In so doing, we first note that most agglomeration models, including NEG/CPT models, suggest that urban input/output externalities are a function of the tier or the size of the urban center (Black and Henderson, 2003) —i.e., there are threshold effects. Marginal growth in an urban center would not measurably affect the size of the input-output externalities within the center—e.g., the scale New York MA's input-output externalities would be only marginally affected if it grew by (say) 5%. Conversely, if the New York MA created 5% more jobs (or any other urban area grew), this could create commuting opportunities in nearby counties, increasing their population growth.

[26]Past empirical research suggests that knowledge spillovers tend have a much smaller geographic scope, perhaps less than a few miles (Rosenthal and Strange, 2001, 2003). The spillovers are often argued to occur through personalized interactions, which limit them to a small geographic scale (Ottaviano and Puga 1998). Thus, we expect that knowledge spillovers play a minor role at most in our urban interaction effects. Spillovers may become less important as an industry matures and their product becomes standardized, which leads to a spatial dispersal of the industry (Rossi-Hansberg, 2005).

By controlling for job growth in the urban center, we could ascertain how much of its job growth spills over and creates opportunities in neighboring counties. Thus, if the incremental (urban center) distance coefficients are smaller in magnitude when the urban commuting measures (employment growth) are included in the model, this would suggest that some of the incremental distance attenuation affects are due to commuting. Yet, any remaining distance effects would be more likely related to spillovers from threshold effects (e.g., input/output externalities and access to urban amenities).

Thus, to empirically assess this issue, we include measures of urban center employment growth for the same urban-tier categories used above. In this assessment, because commuting effects likely die out after 160kms (100 miles), we set the corresponding nearest urban center employment growth equal to zero if it is further than 160kms from the county. In addition, even within 160kms, commuting effects likely attenuate with distance. Hence, we also include interactions of the nearest urban center's employment growth with the county's distance to the corresponding urban center. Finally, one concern is that population and employment growth are simultaneously related. To account for this endogeneity, we again substitute the relevant 1990-2000 industry mix employment growth as an exogenous proxy for local job growth.

The results for the same four size groupings used above are respectively reported in Table 3. For each group, the first set of results are for the base model from Table 1, though the industry mix growth rate in the surrounding BEA region is omitted so as to not to confound the results.[27] This model is reported primarily for comparison, in which these results are very similar to those in Table 1. The second model for each group adds the industry mix growth rates for the nearest/actual urban center in each size category and the corresponding industry mix-distance interactions.

In the core-rural model, the industry mix terms for the nearest urban center are consistently positively and jointly significant at the 5% level, suggesting nearby urban job growth creates commuting opportunities for rural residents.[28] Likewise, the urban center distance × industry mix interaction terms are all negative and jointly statistically significant at the 5% level. As expected, this means positive urban employment growth effects attenuate for more remote rural counties. Yet, the incremental distance to urban center coefficients are still jointly significant at the 5% level, though their magnitude is about one-third less on

[27]With the exception of the core-rural sample, the own-county industry mix measure is also omitted from these models as the urban center's overall industry mix job growth accounts for localized employment growth.

[28]For the other variables that were reported in the other tables, their coefficients are similar to the base model in Table 1, and are not reported for the sake of brevity.

average.

The core-rural pattern suggests that urban job growth spills over and lifts rural population growth through commuting opportunities, whereas some of the incremental urban accessibility penalty discovered above relates to commuting. However, because the incremental distance coefficients are still large, there appears to be important backward-forward externalities that affect rural population growth. That is, besides commuters, rural businesses appear to benefit from closer accessibility to their suppliers and customers, while rural households gain from better access to urban amenities and services.

Regarding the urban centers, the industry mix employment growth terms and corresponding distance interactions are almost universally insignificant. The overall story is that employment growth in nearby higher-ordered urban centers has little statistical influence on smaller urban center growth—suggesting that commuting ties are not an important driver of interactions between urban centers.[29] Regarding the incremental distance results, the coefficients are approximately unchanged. The general pattern remains that growth in MICROs and small MAs is inversely related to distance from higher-order urban centers, consistent with accessibility to urban centers playing the most important role rather than growth shadows. Finally, for larger urban centers, the results still suggest relatively little spatial interaction. Accounting for commuting patterns does not alter our conclusions about backward-forward externalities. Yet, commuting does not appear to be a strong contributing factor in explaining spatial interaction among urban centers.[30]

5. Conclusion.

The New Economic Geography formalized and extended thinking on how urban systems arise. Yet despite the development of numerous theoretical variants of NEG, and its seeming success in explaining the rise of the American urban hierarchy, there has been a dearth of studies that have examined its ability to explain the evolution of a mature urban system. Indeed, there has generally been very little investigation of the spatial interactions of the modern day urban system (Hanson, 2001; Head and Mayer, 2003; Eeckhout, 2004), particularly between urban core and peripheral regional economies. Therefore, this paper empirically

[29]Generally, finding little evidence that there are commuting linkages between differing MICROs and MAs suggests that the U.S. Census Bureau definitions are conceptually accurate. Specifically, by separating the urban centers into different MICROs and MAs, the Census Bureau has deemed that these urban centers are distinctive from one another.

[30]The insignificance of the industry mix employment growth variables for the urban samples supports our interpretation as them reflecting commuting linkages and not static spatial input-output linkages, which would be more expected to exist between urban areas than between urban and less-populated rural areas.

examined recent U.S. core-periphery population dynamics by investigating the potential link between county population growth in the 1990s and geographic proximity to successively higher-tiered urban areas.

We find that rural counties and smaller urban centers have significant interactions with their nearest urban areas. Yet, we find no evidence consistent with NEG growth research. In fact, there were successive penalties in terms of lower growth the further a rural or smaller urban county was from each higher tier of urban center. Further analysis suggested that urban job growth stimulated rural population growth through commuting opportunities. Yet, other factors, some which may be consistent with NEG, also appeared to cause close proximity to urban areas to stimulate growth in smaller areas.

For counties located in metropolitan areas (MAs) with more than 250,000 people, spatial interactions with higher-tiered urban areas were much less evident. We found only weak evidence of urban growth shadows and that was only around the largest tiered urban centers. Thus, some NEG and CPT theory predictions are not particularly germane for describing the continued evolution of the *existing* American urban system. Likewise, commuting linkages likely play only a small role in describing interactions for the smallest MAs and no role for describing the interactions between larger MAs. Instead, the evidence is most consistent with lower-ordered places benefiting from closer accessibility in their backward-forward linkages, which is consistent with elements of NEG when it is interpreted in a wider geographic context in terms of spillovers. Yet, other factors such as higher-tiered cities possessing specialized consumer services and amenities may also play a role.

Although the motivation of the NEG was primarily to describe the emergence of the American urban system, some of its elements are useful in describing the spatial dynamics of a *mature* urban system. Yet other considerations such as inter-area commuting and consumption of urban amenities also appear to play important roles. The results suggest that rural economic development should focus on further developing nearby urban centers, which serve as regional centers of growth for the broader geographic area. The results also are optimistic that smaller metropolitan areas near larger ones will further develop. Development efforts, however, should be informed by knowledge of which economic sectors underpin the spillover effects, suggesting the need for sector-level analysis of core-periphery growth dynamics.

References

Beeson, Patricia E., David N. DeJong, and Werner Troesken, 2001. "Population growth in U.S. counties, 1840-1990," *Regional Science and Urban Economics* 31(6) 669-99.

Black, Duncan and Vernon Henderson. 1999. "Spatial Evolution of Population and Industry in the United States." *American Economic Review* 89: 321-327.

Black, Duncan and Vernon Henderson. 2003. "Urban Evolution in the USA." *Journal of Economic Geography* 3: 342-372.

Blanchard, O.J. and L.F. Katz. 1992. "Regional Evolutions". *Brookings Papers on Economic Activity,* (1): 1-75.

Brülhart, Marius, 1998. "Economic Geography, Industry Location and Trade: The Evidence," *World Economy* 21(6), 775-801.

Christaller, W. 1933. "Central Places in Southern Germany." Translated from *Die Zentralen Orte in Süddeutschland* by Charles W. Baskin. Englewood Cliffs, N.J. Prentice Hall.

Conley, T.G. (1999): "GMM estimation with cross sectional dependence." *Journal of Econometrics* 92: 1-45.

Combes, Pierre-Philippe, 2000. "Economic Structure and Local Growth: France, 1984-1993," *Journal of Urban Economics* 47, 329-355.

Combes, Pierre-Philippe and Henry G. Overman, 2003. "The Spatial Distribution of Economic Activities in the EU," C.E.P.R. Discussion Papers, CEPR Discussion Papers: 3999.

Davis, D. and D. Weinstein. 2002. "Bones, Bombs, and Break Points: The Geography of Economic Activity." *American Economic Review,* 92: 1269-1289.

Desmet, Klaus, and Marcel Fafchamps, 2005. "Changes in the Spatial Concentration of Employment across US Counties: A Sectoral Analysis 1972-2000," *Journal of Economic Geography* 5(3), 261-84.

Dobkins Linda H. and Yannis M. Ioannides. 2001. "Spatial Interactions Among Cities." *Regional Science and Urban Economics* 31: 701-731.

Eeckhout, Jan. 2004. "Gibrat's Law for (All) Cities." *American Economic Review,* 94: 1429-1451.

Fujita, Masahisa, 1988. "A Monopolistic Competition Model of Spatial Agglomeration," *Regional Science and Urban Economics* 18(February), 87-124.

Fujita, Masahisa and Tomoya Mori. 1996. "The Role of Ports in the Making of Major Cities: Self Agglomeration and Hub-Effect." *Journal of Development Economics,* 49: 93-120.

_________.1997. "Structural Stability and Evolution of Urban Systems." *Regional Science and Urban Economics,* 27: 399-442.

Fujita, Masahisa, Paul Krugman, and Tomoya Mori. 1999. "On the Evolution of Hieracrchical Urban Systems." *European Economic Review.* 43: 209-251.

Fujita, Masahisa and Jacques-Francois Thisse, 1996. "Economics of Agglomeration," *Journal of the Japanese and International Economies.* 10(4): 339-78.

Gabaix, Xavier. 1999. "Zipf's Law for Cities: An Explanation." *Quarterly Journal of Economics.* 114: 739-767.

Glaeser, Edward L., 1997. Are Cities Dying? *Journal of Economic Perspectives* 12(2), 139-60.

Glaeser, Edward L., Heidi Kallal, Jośe Sheinkman, and Andrei Schleifer, 1992. "Growth in Cities," *Journal of Political Economy* 100(6), pp. 1126-52.

Glaeser, Edward L. and Janet E. Kohlhase, 2004. "Cities, Regions and the Decline of Transport Costs," *Papers in Regional Science* 83(1), 197-228.

Glaeser, Edward L., Jose A. Scheinkman, and Andrei Schleifer, 1995. "Economic Growth in a Cross-Section of Cities," *Journal of Monetary Economics* 36(1), pp. 117-43.

Hanson, Gordon H., 1997. "Increasing Returns, Trade and the Regional Structure of Wages," *Economic Journal* 107, 113-33.

Hanson, Gordon H. 1998a. "Market Potential, Increasing Returns, and Geographic Concentration." *NBER Working Paper # 6429.*

_____. 1998b. "Regional Adjustment to Trade Liberalization." *Regional Science and Urban Economics* 28: 419-444.

_____. 2001. "Scale Economies and Geographic Concentration of Industry." *Journal of Economic Geography,* 1: 255-276.

Head, Keith and Thierry Mayer. 2003. "The Empirics of Agglomeration and Trade." *Handbook of Regional and Urban Economics, vol. 4.* (forthcoming), accessed at http://strategy.sauder.ubc.ca/head/Papers/neat.pdf.

Ioannides, Yannis M. and Henry G. Overman. 2003. "Zipf's Law for Cities: An Empirical Examination." *Regional Science and Urban Economics* 33: 127-137.

Ioannides, Yannis M. and Henry G. Overman, 2004. "Spatial Evolution of the US Urban System," *Journal of Economic Geography*, 4, 131-56.

Krugman, P. 1991. "Increasing Returns and Economic Geography." *Journal of Political Economy* 99: 483-499.
_____, 1993. "First Nature, Second Nature, and Metropolitan Location," *Journal of Regional Science* 33, 129-44.
_____, 1996. "Confronting the Mystery of Urban Hierarchy," *Journal of the Japanese and International Economies* 10(4), 399-418.

Lucas, Robert E. and Esteban Rossi-Hansberg. 2002. "On the Internal Structure of Cities." *Econometrica* 70: 1445-1476.

Ottaviano, Gianmarco I. P. and Diego Puga, 1998. "Agglomeration in the Global Economy: A Survey of the 'New Economic Geography'," *World Economy* 21(6), 707-31.

Overman, Henry G. and Yannis M. Ioannides. 2001. "Cross-Sectional Evolution of the U.S. City Size Distribution." *Journal of Urban Economics, 49: 543-566.*

Partridge, M.D., M. R. Olfert, and A. Alasia. forthcoming a. "Agglomeration or Amenities: Canadian Cities as Regional Engines of Growth." *Canadian Journal.*

Partridge, M.D.; R. Bollman; M.R. Olfert; and A. Alasia. forthcoming b. "Riding the Wave of Urban Growth in the Countryside: Spread, Backwash, or Stagnation." *Land Economics*.
of Economics.

Partridge, M. D. and D.S. Rickman. Forthcoming. *The Spatial Dimension of Economic Performance and American Poverty.* Kalamazoo, MI: W.E. Upjohn Employment Institute.

Puga, Diego, 1999. "The Rise and Fall of Regional Inequalities," *European Economic Review* 43(2), 303-34.

Quigley, John M. 2002. "Rural Policy and the New Regional Economics: Implications for Rural America." Conference proceedings of The New Power of Regions: A Policy Focus for Rural America, Federal Reserve Bank of Kansas City, pp. 7-27. http://www.frbkc.org/PUBLICAT/PowerofRegions/RC02_Quigley.pdf

Rappaport, Jordan. 2004a. "Moving to nice weather." RWP 03-07. Research Division. Federal Reserve Bank of Kansas City.

_____. 2004b. "Why are Population Flows So Persistent?" *Journal of Urban Economics*, 56: 554-580.

Rappaport, Jordan and Jeffrey D. Sachs, 2003. "The United States as a Coastal Nation," *Journal of Economic Growth* 8(1), 5-46.

Rosenthal, Stuart S. and William C. Strange. 2001. "The Determinants of Agglomeration". *Journal of Urban Economics*, 50: 191-229.

_____. 2003. "Evidence on the Nature and Sources of Agglomeration Economies." Prepared for the Handbook of Urban and Regional Economics, Volume 4. accessed from www.rotman.utoronto.ca/~strange on November 22, 2005.

_____. 2005. "The Attenuation of Human Capital Spillovers: A Manhanttan Skyline Approach." University of Toronto Mimeo. Accessed from www.rotman.utoronto.ca/~wstrange, accessed on November 23, 2005.

Rossi-Hansberg, Esteban. 2005. "A Spatial Theory of Trade." *American Economic Review* 95: 1464-1491.

Simon, Curtis. 2004. "Industrial reallocation across US cities, 1977–1997." *Journal of Urban Economics.* 56, 119-143.

Venables, A.J., 1996. "Equilibrium Locations of Vertically Linked Industries," *International Economic Review* 37, 341-59.

Wolf, H.C. 1997. "Patterns of Intra- and Inter-State Trade." *NBER Working Paper No. 5939*.

Table 1: Dependent variable: Percentage Change in U.S. County Population 1990-2000

Variables/var groups	Core Rural Area 2003 Boundaries			Micropolitan Area 2003 Boundaries			Inside MA with pop ≤250,000			MA >250,000
	Dist	Add other **X**	Add State FE	Dist	Add other **X**	Add State FE	Dist	Add other **X**	Add State FE	Full model
Intercept	0.250	18.713	19.454	3.432	27.497	45.514*	-2.483	40.439	7.251	54.297*
	(0.06)	(0.99)	(1.07)	(0.70)	(1.06)	(1.94)	(-0.35)	(1.15)	(0.23)	(1.86)
Distance to nearest or actual urban center	-0.072**	-0.095**	-0.102**	0.030	0.181**	0.119*	0.081**	0.066	0.055	0.188**
	(-4.71)	(-6.64)	(-7.88)	(0.58)	(2.88)	(1.94)	(2.10)	(1.31)	(1.32)	(4.17)
Inc Dist to MA	-0.050**	-0.040**	-0.038**	-0.038**	-0.036**	-0.025**	n.a.	n.a.	n.a.	n.a.
	(-5.91)	(-5.05)	(-5.23)	(-3.06)	(-3.23)	(-2.11)				
Inc Dist to MA>250k	-0.026**	-0.026**	-0.030**	-0.027**	-0.034**	-0.028**	-0.029**	-0.038**	-0.056**	n.a.
	(-6.24)	(-6.55)	(-5.74)	(-3.73)	(-5.16)	(-3.11)	(-3.27)	(-4.31)	(-5.31)	
Inc Dist to MA>500k	-0.006	-0.004	-0.018**	-0.002	-0.008	-0.009	0.006	0.008	-0.023*	0.012
	(-0.83)	(-0.59)	(-2.59)	(-0.22)	(-0.80)	(-0.77)	(0.37)	(0.65)	(-1.90)	(0.86)
Inc Dist to MA>1500k	-0.006	-0.007*	-0.011**	0.0001	0.003	0.003	-0.0006	-0.006	-0.026**	0.001
	(-1.42)	(-1.68)	(-2.64)	(0.03)	(0.69)	(0.57)	(-0.07)	(-0.77)	(-2.29)	(0.16)
Population density	N	-0.064**	-0.055**	N	-0.018	-0.024**	N	-0.019**	-0.022**	0.0004*
		(-2.42)	(-2.21)		(-1.42)	(-2.01)		(-3.31)	(-4.17)	(1.74)
Pop of nearest or actual urban center	N	1.4E-06	6.8E-06*	N	-5.3E-05**	-2.1E-05	N	1.2E-05	4.3E-05**	-5.2E-07
		(0.25)	(1.71)		(-2.46)	(-1.09)		(0.73)	(3.41)	(-1.63)
Inc pop of nearest MA	N	-1.7E-07**	-1.4E-07	N	-1.5E-06*	-9.8E-07	N	n.a.	n.a.	n.a.
		(-1.99)	(-0.18)		(-1.68)	(-1.12)				
Inc pop of MA>250k	N	-1.2E-07**	-5.5E-07	N	-6.6E-07	-4.5E-07	N	5.1E-07	8.8E-07*	n.a.
		(-2.29)	(-1.05)		(-1.04)	(-0.69)		(0.92)	(1.65)	
Inc pop of MA>500k	N	-1.1E-07**	-4.5E-07	N	-5.0E-07	-2.8E-07	N	-1.1E-06**	-2.9E-07	-3.2E-07
		(-2.41)	(-0.99)		(-1.39)	(-0.71)		(-2.58)	(-0.70)	(-1.08)
Inc pop of MA>1500k	N	-7.0E-07**	-2.3E-07	N	-6.2E-07**	-2.2E-07	N	-8.8E-07**	3.1E-07	-5.1E-07**
		(-4.08)	(-1.13)		(-4.13)	(-1.37)		(-2.58)	(0.85)	(-2.71)
Pop in surrounding counties	N	2.2E-07	-1.9E-07	N	2.5E-08	2.4E-07	N	-1.9E-07	-5.2E-07	4.1E-07*
		(0.76)	(-0.75)		(0.05)	(0.51)		(-0.45)	(-1.47)	(1.88)
Weather/Amenity[a]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Economic/Demographic[b]	N	Y	Y	N	Y	Y	N	Y	Y	Y
Surrounding Econ/Demog[c]	N	Y	Y	N	Y	Y	N	Y	Y	Y
State fixed effects (FE)	N	N	Y	N	N	Y	N	N	Y	Y
R^2	0.33	0.49	0.60	0.24	0.52	0.63	0.17	0.51	0.63	0.63
N	1300	1300	1300	672	672	672	416	416	416	641
F-statistic										
All MA pop = 0	N	3.28**	2.00*	N	3.73**	0.50	N	2.73**	2.62**	1.21
Inc MA pop = 0	N	3.87**	0.53	N	2.71**	0.39	N	3.60**	1.16	1.74
Inc distance to MA = 0	9.38**	17.62**	12.28**	8.11**	11.58**	4.24**	3.57**	5.64**	7.06**	6.00**

Notes: t-statistics are in the parentheses. They are derived from the Conley (1999) estimator which allows spatial correlation in errors and uses a quadratically declining weighting scheme that becomes zero beyond 200 km. ** and * indicate significant at ≤ 5% and ≤ 10% level respectively. N=not included, Y=included.

a = sunshine hours, January temperature, July humidity, typography, amenity ranking, and percent water area.

b = 1989 median household income, 1990-2000 industry mix emp. growth, 1990 unemp. rate, 1990 share ag. emp., 1990 share goods emp., 6 age-distribution variables for 1990, 4 education categories for 1990, 5 race/ethnicity variables for 1990, and percentage of population immigrated during 1985-90.

c = weighted average 1989 median household income, 1990-2000 industry mix emp. growth, and 1990 unemp. rate in surrounding counties within a BEA region.

Table 2: Dependent variable: Percentage Change in U.S. County Population 1980-2000

Variables/var groups	Core Rural Area 2003 Boundaries			Micropolitan Area 2003 Boundaries			Inside MA with pop ≤ 250,000			MA >250,000
	Dist	Add other **X**	Add State FE	Dist	Add other **X**	Add State FE	Dist	Add other **X**	Add State FE	Full model
Intercept	-13.526*	-13.375	22.832*	-11.704	8.150	103.109**	-35.840**	-17.501	-23.874	46.878*
	(-1.75)	(-1.61)	(1.68)	(-0.93)	(0.68)	(3.66)	(-2.26)	(-1.21)	(-0.67)	(1.94)
Distance to nearest or actual urban center	-0.092**	-0.090**	-0.125**	-0.152	-0.097	-0.201	0.001	-0.198*	-0.332**	0.116
	(-3.34)	(-3.07)	(-4.38)	(-1.39)	(-0.61)	(-1.15)	(0.02)	(-1.90)	(-3.50)	(1.42)
Inc Dist to MA	-0.081**	-0.075**	-0.058**	-0.061*	-0.079**	-0.060**	n.a.	n.a.	n.a.	n.a.
	(-5.22)	(-4.59)	(-3.73)	(-1.81)	(-2.29)	(-1.96)				
Inc Dist to MA>250k	-0.044**	-0.037**	-0.057**	-0.056**	-0.059**	-0.057**	-0.065**	-0.086**	-0.184**	n.a.
	(-6.24)	(-5.21)	(-5.06)	(-3.39)	(-3.38)	(-2.95)	(-3.54)	(-4.47)	(-6.05)	
Inc Dist to MA>500k	-0.023*	-0.014	-0.050**	-0.026	-0.048**	-0.042*	0.003	0.034	-0.077*	-0.153**
	(-1.74)	(-0.92)	(-3.28)	(-1.56)	(-2.14)	(-1.66)	(0.09)	(1.33)	(-1.91)	(-4.24)
Inc Dist to MA>1500k	-0.017**	-0.018**	-0.020**	-0.012	-0.012	0.018	-0.011	-0.008	-0.070**	-0.034
	(-2.19)	(-2.17)	(-2.29)	(-1.02)	(-0.89)	(1.13)	(-0.67)	(-0.55)	(-2.30)	(-1.55)
Population density	N	-0.008	-0.010	N	-0.046	-0.072*	N	-0.059**	-0.055**	-0.0008
		(-0.13)	(-0.18)		(-1.29)	(-1.94)		(-3.24)	(-3.18)	(-0.99)
Pop of nearest or actual urban center	N	8.3E-08	1.2E-05	N	-0.0002**	-2.4E-05	N	-8.1E-05*	-2.5E-05	-1.5E-06*
		(0.01)	(1.40)		(-2.45)	(-0.42)		(-1.72)	(-0.64)	(-1.89)
Inc pop of nearest MA	N	-3.6E-06*	-3.4E-08	N	-3.7E-06**	-1.5E-07	N	n.a.	n.a.	n.a.
		(-1.85)	(-0.02)		(-1.03)	(-0.04)				
Inc pop of MA>250k	N	-2.9E-06**	-8.4E-07	N	-5.2E-06**	-1.7E-06	N	2.4E-06	2.5E-06*	n.a.
		(-2.16)	(-0.63)		(-2.56)	(-0.87)		(1.38)	(1.70)	
Inc pop of MA>500k	N	-2.0E-06*	-1.7E-07	N	-1.0E-06	-9.2E-07	N	-2.4E-06**	-1.2E-06	-1.1E-06
		(-1.88)	(-0.16)		(-1.09)	(-0.83)		(-2.04)	(-0.85)	(-1.32)
Inc pop of MA>1500k	N	-4.1E-07	3.4E-07	N	-9.4E-07**	-1.7E-07	N	-9.9E-07	1.9E-06*	-1.3E-06**
		(-0.83)	(0.74)		(-2.62)	(-0.42)		(-1.09)	(1.85)	(-2.22)
Pop in surrounding counties	N	2.0E-06**	9.1E-07*	N	1.1E-06	1.0E-06	N	8.0E-08	-5.5E-07	2.3E-06**
		(3.46)	(1.67)		(1.25)	(1.02)		(0.12)	(-0.65)	(3.73)
Weather/Amenity[a]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
State fixed effects (FE)	N	N	Y	N	N	Y	N	N	Y	Y
R^2	0.34	0.36	0.49	0.24	0.26	0.47	0.26	0.31	0.52	0.41
N	1300	1300	1300	672	672	672	441	441	441	616
F-statistic										
All MA pop = 0	N	2.05*	1.27	N	2.80**	0.22	N	4.01**	1.77	0.80
Inc MA pop = 0	N	2.49**	0.43	N	1.77	0.22	N	2.53*	2.02	1.06
Inc distance to MA = 0	26.17**	17.27**	12.30**	5.56**	6.45**	3.88**	4.16**	7.58**	15.67**	8.72**

Notes: t-statistics are in the parentheses. They are derived from the Conley (1999) estimator which allows spatial correlation in errors and uses a quadratically declining weighting scheme that becomes zero beyond 200 km. ** and * indicate significant at ≤ 5% and ≤ 10% level respectively. N=not included, Y=included.
a = sunshine hours, January temperature, July humidity, typography, amenity ranking, and percent water area.

Table 3: Dependent variable: Percentage Change in U.S. County Population 1990-2000

Variables/var groups	Core Rural 2003		Micropolitan area 2003		Inside MA ≤ 250,000		Inside MA > 250,000	
	Base Model	Full Model	Base Model	Full Model	Base Model	Full Model	Base Model	Full Model
Intercept	24.225	25.195	92.418**	62.614**	32.797	28.226	84.577**	77.256**
	(1.32)	(1.39)	(3.66)	(2.79)	(0.95)	(0.85)	(2.93)	(2.64)
Dist to nearest or actual urban center	-0.103**	-0.070**	0.006	-0.144	0.054	0.033	0.173**	0.198**
	(-7.96)	(-3.50)	(0.09)	(-0.56)	(1.33)	(0.63)	(3.92)	(4.15)
Inc Dist to MA	-0.039**	-0.015*	-0.034**	-0.043**	n.a.	n.a.	n.a.	n.a.
	(-5.27)	(-1.67)	(-2.61)	(-2.39)				
Inc Dist to MA>250k pop	-0.030**	-0.026**	-0.033**	-0.026**	-0.065**	-0.084**	n.a.	n.a.
	(-5.77)	(-4.79)	(-3.40)	(-2.54)	(-5.66)	(-5.42)		
Inc Dist to MA>500k pop	-0.019**	-0.013	-0.009	-0.017	-0.024*	-0.034*	-0.005	0.005
	(-2.68)	(-1.63)	(-0.69)	(-1.22)	(-1.70)	(-1.90)	(-0.42)	(0.22)
Inc Dist to MA>1500k pop	-0.011**	-0.007	0.006	-0.001	-0.021*	-0.022	-0.004	-0.008
	(-2.64)	(-1.62)	(0.89)	(-0.12)	(-1.75)	(-1.45)	(-0.54)	(-0.70)
Industry mix growth 1990-2000	98.669**	95.338**	N	N	N	N	N	N
	(6.79)	(6.67)						
Indmixgr of micropolitan area	N	4.675	N	152.214**	N	N	N	N
		(0.33)		(5.99)				
Indmixgr of MA <250k	N	29.895**	N	-20.727	N	9.184	N	N
		(2.70)		(-1.29)		(0.33)		
Indmixgr of MA 250k to 500k	N	18.638**	N	15.974	N	-26.325	N	12.958
		(1.99)		(1.18)		(-1.42)		(0.96)
Indmixgr of MA 500k to 1500k	N	27.499**	N	14.853	N	-36.693	N	26.755
		(2.38)		(1.11)		(-1.45)		(1.40)
Indmixgr of MA>1500k	N	61.689**	N	4.084	N	-13.440	N	8.441
		(3.13)		(0.23)		(-0.61)		(0.41)
Dist x Indmixgr of micropolitan area	N	-0.083	N	0.420	N	N	N	N
		(-0.85)		(0.27)				
Dist x Indmixgr of MA <250k	N	-0.217**	N	0.152	N	-0.055	N	N
		(-2.92)		(1.50)		(-0.28)		
Dist x Indmixgr of MA 250k to 500k	N	-0.080	N	-0.150*	N	0.157	N	-0.011
		(-1.04)		(-1.71)		(1.11)		(-0.11)
Dist x Indmixgr of MA 500k to 1500k	N	-0.198**	N	-0.150*	N	0.246*	N	-0.109
		(-2.46)		(-1.70)		(1.68)		(-0.87)
Dist x Indmixgr of MA >1500k	N	-0.376**	N	-0.067	N	-0.021	N	-0.030
		(-2.64)		(-0.53)		(-0.13)		(-0.25)
R^2	0.60	0.61	0.59	0.63	0.62	0.62	0.62	0.62
N	1300	1300	672	672	416	416	641	641
F-statistic								
Inc distance to MA = 0	12.72**	5.45**	6.21**	3.20**	8.06**	9.71**	0.13	0.28
Indmixgr of MA = 0	N	5.37**	N	11.42**	N	1.27	N	0.97
Dist x Indmixgr of MA = 0	N	4.56**	N	1.86	N	1.04	N	0.27

Notes: t-statistics are in the parentheses. They are derived from the Conley (1999) estimator which allows spatial correlation in errors and uses a quadratically declining weighting scheme that becomes zero beyond 200 km. ** and * indicate significant at ≤ 5% and ≤ 10% level respectively. N=not included.
All models included 6 weather/amenity variables: sunshine hours, January temperature, July humidity, typography, amenity ranking, and percent water area; 6 economic variables: 1989 median household income, 1990 unemployment rate, 1990 share agriculture emp, 1990 share goods emp, weighted average 1989 median household income, and 1990 unemployment rate in surrounding counties within a BEA region; 6 age-distribution variables for 1990; 4 education categories for 1990; 5 race/ethnicity variables for 1990; percentage of population immigrated during 1985-90, 1990 population in surrounding counties within a BEA region, and state fixed effect variables.

Appendix Table 1: Variable Definitions and Descriptive Statistics (full sample)

Variable	Description	Source	Mean	St. dev.
Population change	Percentage change in total population over 1990-2000 (or 1980 to 2000)	1980, 1990, 2000 Census	11.22	16.00
Dist to nearest/actual urban center (micropolitan or metropolitan area, CBSA)	Distance (in km) between centroid of a county and population weighted centroid of the nearest urban center, if the county is not in an urban center. It is the distance to the centroid of its own urban center if the county is a member of an urban center (in kms).	1990 Census, C-RERL	34.61	32.44
Inc dist to metro	Incremental distance to the nearest/actual metropolitan area in kms (see text for details)	Authors' est.	36.68	49.06
Inc dist to metro>250k	Incremental distance to the nearest/actual metropolitan area with at least 250,000 population in 1990 in kms (see text for details)	Authors' est.	56.29	97.27
Inc dist to metro>500k	Incremental distance to the nearest/actual metropolitan area with at least 500,000 population in 1990 in kms (see text for details)	Authors' est.	40.67	66.83
Inc dist to metro>1500k	Incremental distance to the nearest/actual metropolitan area with at least 1,500,000 population in 1990 in kms (see text for details)	Authors' est.	89.77	111.47
Population density	1990 county population per square mile	1990 Census	207.83	1,593.40
Nearest/Actual Urban Center pop	1990 Population of the nearest/actual urban center measured as a micropolitan or metropolitan area (see text for details).	Authors' est.	374,271.3	1,377,909.3
Inc pop of nearest metro	Incremental population of the nearest/actual metropolitan area, 1990 (see text for details)	Authors' est.	186,155.0	457,600.8
Inc pop of metro>250k	Incremental population of the nearest/actual metropolitan area with at least 250,000 population in 1990 (see text for details)	Authors' est.	475,334.1	908,103.9
Inc pop of metro>500k	Incremental population of the nearest/actual metropolitan area with at least 500,000 population in 1990 (see text for details)	Authors' est.	613,128.6	1,263,115.2
Inc pop of metro>1500k	Incremental population of the nearest/actual metropolitan area with at least 1,500,000 population in 1990 (see text for details)	Authors' est.	1,235,251.3	2,159,221.8
Weather/Amenity				
Sun hours	Mean January sun hours	ERS, USDA	151.41	33.21
January temp	Mean January temperature (degree F)	ERS, USDA	32.95	12.07
July humidity	Mean July relative humidity (%)	ERS, USDA	56.15	14.49
Typography	Typography score 1 to 24, in which 24 represents the most mountainous terrain	ERS, USDA	8.83	6.59
Amenity rank	Natural amenity rank 1 to 7, with 7 being the highest	ERS, USDA	3.49	1.04
Percent water	Percent of county area covered by water	ERS, USDA	4.61	11.29
Economic/Demographic				
Median HH inc	Median household income 1989	1990 Census	23,842.70	6,388.75
Industry mix growth	Industry mix employment growth, calculated by multiplying each industry's national employment growth (between 1990 and 2000) by the initial period (1990) industry employ. shares in each sector	1990, 2000 BEA, Regional Econ. Info. System, Authors' est.	0.16	0.04
Unemployment rate	1990 Civilian unemployment rate (%)	1990 Census	6.67	3.02
Agriculture share	1990 Percent employed in agriculture sector	1990 Census	8.45	8.20
Goods share	1990 Percent empl. in (nonfarm) goods sector	1990 Census	27.28	10.19
Percent pop under 6 years	Percent of 1990 population under 6 years	1990 Census	10.08	1.45
Percent pop 7-17 years	Percent of 1990 population 7-17 years	1990 Census	16.78	2.34
Percent pop 18-24 years	Percent of 1990 population 18-24 years	1990 Census	9.18	3.43
Percent pop 55-59 years	Percent of 1990 population 55-59 years	1990 Census	4.56	0.73
Percent pop 60-64 years	Percent of 1990 population 60-64 years	1990 Census	4.70	0.98
Percent pop 65+ years	Percent of 1990 population over 65 years	1990 Census	14.97	4.33
Percent HS graduate	Percent of 1990 population 25 years and over that are high school graduates	1990 Census	34.36	6.12
Percent some college	Percent of 1990 population 25 years and over that have some college degree	1990 Census	16.39	4.50
Percent associate degree	Percent of 1990 population 25 years and over that have an associate degree	1990 Census	5.34	2.10

Percent college graduate	Percent of 1990 population 25 years and over that are 4-year college graduates	1990 Census	13.43	6.45
Percent Hispanic	Percent of 1990 population Hispanic	1990 Census	4.37	10.96
Percent African American	Percent of 1990 population African-American	1990 Census	8.60	14.32
Percent Asian-Pacific	Percent of 1990 population Asian and Pacific islands origin	1990 Census	0.59	1.26
Percent Native American	Percent of 1990 population that are Native American	1990 Census	1.44	5.59
Percent other race	Percent of 1990 pop. with other race background	1990 Census	1.80	4.57
Percent immig 1985-90	Percent of 1990 pop. immigrated over 1985-90	1990 Census	0.48	0.96
Surrounding Variables				
Population density_surr	Weighted average population density in surrounding counties within a BEA region[a]	1990 Census, Authors' est.	663.44	1,553.27
Median HH inc_surr	Weighted average median household income in surrounding counties within a BEA region[a]	1990 Census, Authors' est.	26,753.68	4795.66
Industry mix growth_surr	Weighted average industry mix employment growth in surrounding counties within a BEA region[a]	1990 BEA, Regional Econ. Info. System Authors' est.	0.19	0.02
Unemployment rate_surr	Weighted average total civilian unemployment rate in surrounding counties within a BEA region[a]	1990 Census, Authors' est.	6.25	1.55
State fixed effects (FE)	Dummy variables		n.a.	n.a.
N			3029	

Notes: Centroids are population weighted. The metropolitan/micropolitan definitions follow from the 2003 definitions. BEA = Bureau of Economic Analysis; ERS, USDA = Economic Research Services, U.S. Department of Agriculture; C-RERL = Canada Rural Economy Research Lab, University of Saskatchewan. See Partridge and Rickman (forthcoming) for more details of the variable sources and sample selection.

a. The surrounding BEA region variables are calculated as the average of the region net of the county in question. The BEA economic regions are 177 functional economic areas constructed by the BEA.

Appendix Table 2: Mean and Standard Deviations (in parentheses) of Major Variables by Population Group

Variables	Core Rural	Micropolitan	MA≤ 250,000	MA>250,000
Distance to nearest or actual urban center	59.91 (30.56)	4.63 (9.63)	17.76 (18.60)	28.60 (19.52)
Inc dist to MA	43.47 (49.93)	78.46 (46.97)	n.a.	n.a.
Inc dist to MA>250k	76.02 (115.19)	48.96 (83.41)	93.23 (93.26)	n.a.
Inc dist to MA>500k	45.32 (68.95)	38.17 (59.87)	36.87 (59.07)	36.29 (73.34)
Inc dist to MA>1500k	83.45 (106.24)	99.81 (119.29)	78.54 (115.44)	99.37 (139.88)
Population density	23.01 (20.06)	61.14 (45.95)	119.96 (123.82)	793.46 (3,399.82)
Pop of nearest or actual urban center	73,743.63 (112,327.21)	48,875.11 (26,764.12)	138,285.46 (45,144.03)	1,698,737.27 (2,685,450.02)
Inc pop of nearest MA	183,099.40 (368,656.31)	274,366.21 (480,896.37)	n.a.	n.a.
Inc pop of MA>250k	533,758.31 (872,740.78)	460,874.87 (776,502.89)	1,048,541.50 (1,403,056.67)	n.a.
Inc pop of MA>500k	648,040.08 (992,727.71)	619,122.45 (1,159,943.19)	619,832.98 (1,231,175.82)	531,690.68 (1,773,562.46)
Inc pop of MA>1500k	1,097,303.21 (1,611,653.76)	1,385,394.92 (2,167,150.57)	1,048,521.20 (1,708,339.55)	1,478,848.73 (3,134,548.98)
Pop in surrounding BEA Region	1,403,864.58 (1,766,306.24)	1,788,083.84 (2,190,149.41)	2,056,142.57 (2,594,486.02)	3,404,505.62 (4,493,830.62)
Sample size	1300	672	416	641

Notes: The categories are determined using 2003 definitions. See the text for more details.

Appendix Table 3: Dependent variable: % Change in U.S. County Population 1990-2000 Using Alternative Boundaries & Definitions

Variables/var groups	Non-MA 2003	Non-MA 1999 Boundaries Dist	Add other **X**	Add State FE	MA 1999 Boundaries with pop ≤ 250,000 Dist	Add other **X**	Add State FE	MA 1999>250,000 Full model
Intercept	26.164*	2.567	23.520	29.274**	-6.001	107.598*	11.996	26.227
	(1.80)	(0.71)	(1.49)	(2.07)	(-0.63)	(1.74)	(0.21)	(0.75)
Distance to nearest or actual	-0.085**	-0.089**	-0.085**	-0.094**	0.211**	0.062	0.034	0.172**
urban center	(-8.25)	(-8.56)	(-7.63)	(-8.98)	(2.79)	(1.30)	(0.81)	(4.36)
Inc Dist to MA	-0.040**	-0.065**	-0.059**	-0.055**	n.a.	n.a.	n.a.	n.a.
	(-6.06)	(-8.12)	(-8.09)	(-8.02)				
Inc Dist to MA>250k	-0.030**	-0.027**	-0.031**	-0.033**	-0.018**	-0.032**	-0.054**	n.a.
	(-6.41)	(-6.44)	(-7.77)	(-6.68)	(-2.07)	(-3.66)	(-4.64)	
Inc Dist to MA>500k	-0.019**	-0.002	-0.003	-0.015**	0.016	0.013	-0.009	0.005
	(-2.72)	(-0.33)	(-0.50)	(-2.08)	(0.95)	(0.98)	(-0.61)	(0.34)
Inc Dist to MA>1500k	-0.007*	-0.0008	-0.002	-0.008**	-0.005	-0.005	-0.013	0.002
	(-1.86)	(-0.21)	(-0.60)	(-2.13)	(-0.48)	(-0.56)	(-0.88)	(0.21)
Population density	-0.057**	N	-0.061**	-0.065**		-0.012*	-0.019**	0.0005**
	(-6.02)		(-7.79)	(-8.29)	N	(-1.87)	(-3.90)	(2.27)
Pop of nearest or actual urban	6.3E-06	N	6.0E-06*	1.0E-05**		9.9E-06	4.1E-05**	-6.9E-07**
center	(1.62)		(1.88)	(3.23)	N	(0.43)	(2.48)	(-2.06)
Inc pop of nearest MA	-1.3E-07	N	-6.0E-07	3.0E-07		n.a.	n.a.	n.a.
	(-0.22)		(-0.87)	(0.49)	N			
Inc pop of MA>250k	-5.2E-07	N	-5.0E-07	-2.3E-07		4.2E-07	-1.6E-07	n.a.
	(-1.22)		(-1.15)	(-0.59)	N	(0.65)	(-0.23)	
Inc pop of MA>500k	-2.2E-07	N	-9.1E-07**	-4.9E-07*		-8.4E-07	-3.3E-07	-3.7E-07
	(-0.75)		(-2.86)	(-1.67)	N	(-1.32)	(-0.58)	(-1.34)
Inc pop of MA>1500k	-1.7E-07	N	-8.5E-07**	-4.0E-07**		-8.7E-07*	9.0E-08	-4.8E-07**
	(-1.25)		(-6.28)	(-2.55)	N	(-1.71)	(0.19)	(-2.67)
Pop in surrounding counties	-1.9E-08	N	2.6E-07	2.0E-07		-5.5E-08	-3.9E-07	3.6E-07*
	(-0.07)		(0.99)	(0.79)	N	(-0.09)	(-0.74)	(1.68)
Weather/Amenity[a]	Y	Y	Y	Y	Y	Y	Y	Y
Economic/Demographic[b]	Y	N	Y	Y	N	Y	Y	Y
Surrounding Econ/Demog[c]	Y	N	Y	Y	N	Y	Y	Y
State fixed effects (FE)	Y	N	N	Y	N	N	Y	Y
R^2	0.59	0.31	0.49	0.59	0.17	0.56	0.72	0.65
N	1972	2205	2205	2205	265	265	265	559
F-statistic								
All metro pop = 0	2.00*	N	10.21**	10.10**	N	0.99	1.11	1.38
Inc metro pop = 0	0.62	N	8.62**	1.93*	N	1.30	0.07	1.65
Inc distance to metro = 0	20.02**	20.34**	45.71**	31.14**	1.47**	3.15**	4.23**	0.06

Notes: t-statistics are in the parentheses. They are derived from the Conley (1999) estimator which allows spatial correlation in errors and uses a quadratically declining weighting scheme that becomes zero beyond 200 km. ** and * indicate significant at ≤ 5% and ≤ 10% level respectively. N=not included, Y=included.

a = sunshine hours, January temperature, July humidity, typography, amenity ranking, and percent water area.

b = 1989 median household income, 1990-2000 industry mix emp. growth, 1990 unemp. rate, 1990 share ag. emp., 1990 share goods emp., 6 age-distribution variables for 1990, 4 education categories for 1990, 5 race/ethnicity variables for 1990, and percentage of population immigrated during 1985-90.

c = weighted average 1989 median household income, 1990-2000 industry mix emp. growth, and 1990 unemp. rate in surrounding counties within a BEA region.