Lost in Space: Population Dynamics in the American Hinterlands and Small Cities

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Abstract: The sources of urban agglomeration and the urban hierarchy have been extensively studied. Despite the pivotal role of the hinterlands in theories of the development of the urban hierarchy, little attention has been paid to the effect of urban agglomeration on growth in the hinterlands, particularly in a developed, mature economy. Therefore, this study examines how proximity to urban agglomeration affects contemporary population growth in hinterland U.S. counties. Proximity to urban agglomeration is measured in terms of both distances to higher-tiered areas in the urban hierarchy and proximity to market potential. Particular attention is paid to whether periodic changes and trends in underlying conditions (e.g., technology or transport costs) have altered population dynamics in the hinterlands and small urban centers. Over the period 1950-2000, we find strong negative growth effects of distances to higher-tiered urban areas, with significant, but lesser, effects of distance to market potential. Further, the costs of distance, if anything, appear to be increasing over time, consistent with various recent theories stressing the importance of how new technology affects the spatial distribution of activity in a mature urban system, while factors associated with the New Economic Geography are of lesser importance.

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Keywords: Agglomeration; New Economic Geography; Urban Hierarchy; Population Growth

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1. INTRODUCTION

The evolution of an urban system has generated extensive theoretical and empirical investigation. From Central Place Theory (CPT) as conceptualized by Christaller (1933) and Lösch (1954), to the New Economic Geography (NEG) and its refinements, the development of an urban hierarchy of core-periphery regions has been of sustaining interest (Krugman, 1991; Fujita and Krugman 2004; Tabuchi et al., 2005). The hinterlands and small urban areas play a key role in the explanations for the development of urban systems in both CPT and NEG, as markets, as resource bases, and as potential sources for new urban centers. In fact, using various definitions described below, the "lost" hinterlands and small urban centers accounted for up to 53% of U.S. population in 1990. While numerous studies have explored the empirical regularities of the urban system such as the rank order of cities (Gabaix, 1999; Eeckhout, 2004; Duranton, 2007), population dynamics of the hinterlands and small urban areas within the context of a *mature* urban system have been relatively neglected.

The U.S. urban system appears to be relatively mature and stable, especially at the top. For example, 29 of the top 30 MAs in 1950 in terms of population remained in the top 30 in 2003. Indeed, Zipf's Law, which implies a system of cities with a fairly stable relative size distribution, has proven remarkably resilient to repeated testing, especially at the upper end of the city size distribution (Ioannides and Overman, 2003; Eckhout 2004; Duranton, 2007). It appears that the uniform plain has been replaced with a stable lattice of mature cities, with new smaller cities arising from time to time in the hinterlands.

Stability at the top tiers of the urban hierarchy relegates the other end of the distribution to the periphery or hinterland category. Yet, the hinterlands are not homogeneous in terms of their growth potential since it is, after all, these spaces that spawn new urban centers when population concentrations reach critical sizes. For the hinterlands, analogous to the growth determinants of the largest centers, site attributes (first and second nature) are important. Within the mature urban system, technological shocks and differing sectoral propensities to innovate also can spillover into the hinterlands, affecting population growth dynamics (e.g. Duranton and Puga, 2001). Nowhere is the impact of labor-saving technological change on population more evident than the long-term rural decline in the farm-dependent Great Plains region. Hence, whereas the NEG has proven very useful in understanding the emergence of urban systems, this orientation is less useful for appraising hinterland population dynamics in a mature system.

More importantly perhaps, assessment of growth in the hinterlands and small urban centers should include consideration of their spatial proximity relative to the upper, stable tiers of the urban hierarchy. Glaeser et al. (2001) and Tabuchi and Thisse (2006) emphasize the importance of access to amenities and services provided in the largest urban areas. Yet, the factors that propel and limit metropolitan growth—agglomeration, industry mix, competition and congestion—will influence nonmetro growth dynamics, but their spillovers to the hinterlands and small urban areas are largely transmitted over longer distances from larger metro areas. Hinterland access to higher-order services and to urban jobs through commuting is often referred to as 'spread effects' (Henry et al. 1997; Partridge et al. 2007a, 2007b).

Introducing the specific proximity of a location within the urban system implies that the transmission of agglomeration benefits over space has a discontinuous effect with discrete and tier-specific changes in the influence of urban centers. While the NEG emphasis on access to markets and suppliers provides a partial reflection of distance effects, the role of proximity to the spatial structure of the urban system has received less attention. The relative importance of proximity to tiers of the urban hierarchy versus alternative effects such as (NEG) market potential can be best empirically investigated by representing space in a continuous manner that also formally distinguishes each the tier of the hierarchy.

There are also periodic shocks that influence dynamics in the hinterlands. Different industry compositions imply varying propensities to innovate and incidence of technological change (Duranton Puga, 2001; Duranton, 2007; Desmet and Rossi-Hansberg, 2007). For example, beginning in the 1970s as new information technologies (IT) took hold in the higher-order service sectors concentrated in large cities, remote hinterland locations would have been relatively disadvantaged due to a lack of access to these services and technologies. This would reinforce ongoing labor-saving technological changes in the primary sector employment base of the hinterlands. Yet, offsetting these effects, the manufacturing sector was on average at a mature stage of its product cycle by the 1950s and thus dispersing to low-cost hinterland locations. Moreover, the impact of falling communication and transportation costs, as illustrated by the large-scale completion of the interstate highway system in the 1970s, favored hinterland locations (e.g., lower cost of transporting the annual harvest). Yet, even if transportation costs fall, new (information-intensive) technologies may be associated with a significant increase in the *frequency* of interaction (McCann, 2007). Thus, proximity and market size considerations would favor urban locations.

These examples illustrate that to fully understand the relationship between proximity in the urban hierarchy and hinterland population dynamics, an examination of both longer time periods and sub-periods is required. Likewise, a flexible definition of the core and the periphery is necessary both because the definition of the 'hinterlands' evolves over time and because industry composition varies between the smallest remote villages and small urban centers. We directly assess peripheral population dynamics of hinterland and small metro areas within the mature American urban hierarchy by explicitly recognizing the influence of distance from tier-differentiated urban centers using differing hinterland definitions.

The next section presents the theoretical framework for our investigation. Our framework relies on concepts and tools that have proven useful in understanding the evolution of an urban system, as well as novel applications of intra- and inter-urban relationships in the mature system. This is followed by sections presenting the empirical model, results, and conclusions.

Among our results, we find that even after accounting for location specific effects such as natural amenities, distance from urban agglomeration economies is shown to be of primary importance in hinterland population dynamics, in which time-period comparisons suggest that proximity is becoming more important. Thus, technological shocks and related industry restructuring have disadvantaged the hinterlands. While past research has identified market potential and amenities as the driving forces for rural population change, we find proximity within the urban system plays a stronger role. Besides broad patterns such as Sunbelt migration, we conclude that the hinterlands' population appears to be redistributing itself to be *nearer* to, if not exactly *in*, larger urban centers. These results appear to be robust across time periods and to a range of sensitivity tests, including what we believe are novel ways to account for possible omitted autoregressive effects or omitted fixed effects associated with endogeneity.

2. THEORETICAL MODEL: SPATIAL INTERACTIONS AND POPULATION DYNAMICS

The agglomeration of economic activity across the American landscape and its geographic scope of influence reflect a multitude of location optimizing decisions by firms and households, forming the basis for numerous theories (Rosenthal and Strange, 2001). Movements of households and firms occur: a) in response to spatially uneven (unanticipated) demand and supply shocks; b) as a result of technology- or preference-driven changes in the role of location/distance; and c) due to imperfect responses of wages and rents. Despite a similarity in their predictions of agglomeration (Brülhart, 1998; Head and Mayer, 2004), different views of the role of distance lead to vastly differing core-periphery population dynamics.

According to traditional 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 as factor prices become equalized. Increasing concentration in many areas, and development of core areas without natural advantages, require other explanations (Krugman, 1993).[1]

One such explanation is the New Economic Geography (NEG) (Krugman, 1991). NEG models incorporate imperfect competition, increasing returns to scale, and perfectly mobile factors. Regions faced with growing demand (market potential) for their increasing-returns-to-scale industries enjoy a competitive advantage, inducing factor inflows (Head and Mayer, 2004, p. 2616). In Krugman's (NEG) models (1991; 1993), labor facilitates agglomeration by responding to higher real wages associated with a diversity of manufactured consumer goods, easing factor market competition.

This narrow role for household location decisions, in neglecting the underlying richness and diversity of considerations including commuting possibilities, may limit the value of NEG models in explaining current regional growth patterns. Mostly due to their analytical tractability, even in richer NEG-type models such as in Tabuchi and Thisse (2006), commuting linkages are *intra* regional and spillovers across regions are mostly limited to trade flows and factor movements. Because of industrial realignment and reduced transportation costs, factors such as knowledge externalities and household location decisions may now be more important sources of continued agglomeration than the pecuniary

[1] Natural advantages such as a port can lead to a lock-in effect where a city thrives (Fujita and Mori, 1996).

externalities of NEG (Glaeser and Kohlhase, 2004; Fujita and Mori, 2005).[2] Reinforcing these patterns are innovations and technological changes related to industry composition that may yield an entirely different core-periphery relationship than predicted by standard NEG theory.

The source of urban agglomeration may affect the nature of urban core-periphery relationships. Market potential in the NEG predicts agglomeration economies to smoothly attenuate with greater distance from the core areas (Hanson, 1998; 2005). However, if the nature of agglomeration economies is differentiated by status in the urban hierarchy, the attenuation of agglomeration economies may contain discrete shifts across the urban hierarchy and into the hinterlands (Eaton and Eckstein, 1997; Brülhart and Koenig, 2006). Thus, population growth would not only be affected by proximity to market potential, but also by proximity to different tiers in the urban hierarchy.

Below we present a general framework to consider various theories and mechanisms for agglomeration of economic activity with an emphasis on its effect on hinterland areas. Our approach follows in the tradition of Roback (1982), in which the current attractiveness of regions to firms and households determines net population movements. A key advantage of our framework is its flexibility in allowing all forms of sources of agglomeration including NEG-pecuniary and urban-amenity sources (Ottaviano and Pinelli 2006; Tabuchi and Thisse, 2006, p. 1299).

2.1 Firm Location

Representative firm *k* maximizes profits (Π^k_i) in its choice of location. Profits are negatively affected by labor costs (w) and land costs (r), and positively affected by natural firm amenities (A^f), and agglomeration economies in the area (S^f) and in other accessible areas (S^f_{ij}). Ignoring time subscripts, the profit function of a representative firm *k* can be expressed as:

(1) $\Pi^k_i = (w_i, r_i, A^f_i, S^f_i, S^f_{ij})$,

where j denotes proximate areas.

From NEG, with its focus on pecuniary effects, close proximity to suppliers of intermediate inputs and customers lowers transportation costs (Venables, 1996), in which scale economies may exist in the production of non-traded intermediate inputs (Fujita, 1988). Home-market effects occur when greater access to market potential produces a competitive advantage (Head and Mayer, 2004). Moreover, input-

[2]Black and Henderson (1999) provide empirical evidence that larger cities are locked-in to their higher status for centuries at a time, though there is more churning among low-tiered cities. Davis and Weinstein (2002) show that even the Allied bombing against Japan during World War II did not significantly alter its long-term urban system.

output linkages likely extend across area boundaries as does trade of final goods.[3] However, the relative increased importance of services and reduction in transportation costs may have weakened these agglomerative upstream and downstream linkages, making NEG less relevant for explaining current population movements (Glaeser and Kohlhase, 2004).

Geographic proximity to the largest cities matters for reasons that extend beyond market potential and pecuniary externalities. Transactions costs such as information costs about demand conditions and locating trusted suppliers increase with distance from the agglomerated areas (Hanson, 1998). Congestion costs, such as higher crime, pollution, and land prices (Glaeser, 1997), associated with the largest agglomeration centers may cause positive growth spillovers to nearby areas. Knowledge externalities likewise can extend beyond city boundaries and labor market pooling provides benefits for firms in proximate areas (Rosenthal and Strange, 2001; 2003). Even as transportation costs decline, frequency of interaction may be increasing (McCann, 2007), making proximity even more important—e.g., the annual harvest may have required only one major transaction. These other factors may be gaining importance in underlying agglomeration effects relative to NEG pecuniary externalities (Glaeser and Kohlhase, 2004; Fujita and Mori, 2005), and may be more prevalent for the largest of cities. For example, Brülhart and Koenig (2006) find discrete changes in core-periphery wage gradients for European capital cities consistent with urban proximity, while Eaton and Eckstein (1997) find hierarchical city-size effects on factor returns in Japan and France.

Therefore, we re-write the indirect firm profits in an area as:

(2) $\Pi^k_i = (w_i, r_i, A^f_i, S^f_i, MP_i, D_{ij})$,

where S_{ij} is replaced by MP_i (market potential) and D_{ij} (distance to higher tiers within the urban hierarchy is formally defined in Section 2.4). Greater market potential should attract resources, including population, into the agglomerated areas (Head and Mayer, 2004), with its effect diminishing smoothly with distances (Hanson, 1998). However, because of potential price competition associated with close proximity, net distance effects on profits can be either positive or negative, likely depending on the size of the urban core(s) from which distance is measured. Discrete differences in the functions of tiers of the urban hierarchy suggest associated discrete shifts in agglomeration-based profits.

[3]For example, Wolf (1997) reports that U.S. domestic goods are shipped an average of 255 miles.

Regions with high profits for the representative firm (Π^k_i) relative to the national average (Π^k_{US}) will on net attract profit-maximizing firms. Profits are not necessarily equalized across regions at any point in time because of changing exogenous conditions (e.g., changes in transportation costs and technology) and adjustment lags. Assuming that labor demand (L^D) is positively related to the net movement of firms and expansion of existing firms, the change in region *i*'s labor demand can be written as:

(3) $\Delta L^D_i = f_i(\Pi^k_i - \Pi^k_{US}), f'_\Pi(\ )>0$.

Assuming that the changing effects of D_{ij} and MP_i are not fully capitalized into factor prices, they reduce (increase) labor demand if they make it less (more) profitable to be located in a more remote area than before, so that $f'_{Dij} < 0$ and $f'_{MP} > 0$ ($f'_{Dij} > 0$ and $f'_{MP} < 0$).

2.2 Household Location

À la Roback (1982), we assume households locate in a region for a myriad of reasons besides the labor demand reasons usually stressed in NEG models. Households locate to maximize utility in the consumption of natural amenities (A^h), man-made amenities such as those related to urbanization (S^h) (Tabuchi and Thisse, 2006), both in region *i* and proximate regions *j*, traded goods (X), and housing (H):

(4) $U_i = U_i(A^h_i, S^h_i, S^h_{ij}, X_i, H_i)$.

Natural amenities include favorable climate and topography conducive to recreation. 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, demands for which may be rising over time (Glaeser, 1997). Although household migration imparts its own competition (congestion) effects, these are likely to be of secondary importance (Combes and Overman, 2003).

The cost of access to urban amenities in proximate regions, as well as commuting to jobs, increases with distance from differentiated higher-tiered urban areas (D_{ij}). The geographic access to diverse work opportunities provided by a large urban center also reduces unemployment risk (Rosenthal and Strange, 2001). Alternatively there are forces that imply that distance has positive effects on utility—i.e., when a rural lifestyle is attractive. Higher crime, pollution, and traffic congestion reduce the attractiveness of the agglomerated core (Glaeser, 1997), dispersing households into rural and exurban areas. On balance then, D has a contemporaneous *a priori* ambiguous effect on household location. Consumption is also constrained by the price of traded goods (p), normalized to equal the national price, and land costs (r) through its influence on housing.[4] Therefore, the corresponding indirect utility function can be written as:

(5) $V_i = V_i(w_i, r_i, p, A^h_i, S^h_i, D_{ij})$.

As for firm profitability, at time *t*, because of changing exogenous factors (e.g., changes in tastes, or transportation costs) and adjustment lags, household utility need not be equalized across regions and geographic proximity need not be capitalized into factor prices. Thus, the change in labor supply (L^S) in region *i* relates to the difference in regional household utility from the rest of the U.S. (V_{ROUS}):

(6) $\Delta L^S_i = g_i(V_i - V_{ROUS})$, where $g'_V(\ )>0$.

2.3 Reduced Form Population Growth Equation

Using equations (1)-(6), a reduced form equation for population growth can be obtained. Traded goods prices are eliminated because of their regional uniformity. Equating factor demands with supplies in equilibrium causes the wage rate and land rent to drop out. Thus, population growth relates to the exogenous factors: market potential, natural and man-made firm and household amenities in the region, and access to hierarchically differentiated man-made household and firm amenities in proximate regions:

(7) $PopGr_i = h_i(A^f_i, S^f_i, MP_i, A^h_i, S^h_i, D_{ij})$.

Population growth is expected to be positively related to market potential; the effect of proximity in the urban hierarchy is ambiguous and potentially varying by the tier from which the distances are measured.[5]

2.4 Measuring Urban Hierarchy Distance Effects

The effect of distance on population growth at a specific location is sensitive to the position and tier of the proximate urban center(s). Cities at each tier offer goods and services that are available in lower-tier cities, plus additional higher-order goods and services. The top tier (n) has the full range of services including the highest-order consulting, financial, and legal services. The first or lowest tier has only the most basic services such as gas stations. Residents and businesses in the first tier must travel to the higher tiers to access second, third, and higher orders of services, etc. At any tier of the hierarchy then, there are marginal costs of accessing incrementally higher-ordered urban services or household amenities.

For area *i* in the j^{th} tier, a distance 'penalty' is summed over $t = j+1$ to the n^{th} tier as:

[4] We assume regional differences in housing prices primarily relate to land rents (Davis and Palumbo, 2006).

[5] If there is some capitalization of changes in the role of urban hierarchy distances and market potential into factor prices, population growth then also depends on how much they respond. Full responses by factor prices would cause population growth to be unaffected. To the extent there are spatial frictions or unanticipated changes in the effects of proximity in the urban hierarchy and market potential, factor prices will not fully capitalize these effects and population growth will adjust until a new spatial equilibrium is established.

(8) $P_{ij} = \sum_t d^t \varphi^t$,

where d is the incremental distance to each higher tier, φ is the marginal population growth effect of greater incremental distance from a tier *t* place, and *n* is the highest tier. Because d^t is the incremental distance to reach each successive tier, summing the *d* terms yields the total distance to the highest n^{th} tier. The φ terms differentiate the marginal distance effects by tier. So *P* reflects the total disadvantage residents and businesses in area *i* (in tier *j*) face to access the full complement of progressively higher-order goods/services and urban amenities up the hierarchy. Yet some or all of the effects on population growth (φ) could be positive if there are benefits of remoteness due to factors such as growth shadows (e.g., particularly for small urban areas). Figure 1 illustrates how the *effects* of distance are differentiated by tier. A higher tier is successively accessed for those services unavailable at each lower tier; tier-specific φ terms yield a non-linear relationship. The total distance penalty/benefit P_{i4} for a given county *i* reflects the full cost of remoteness from all higher-tier centers.

3. EMPIRICAL IMPLEMENTATION

Using U.S. counties as our units of analysis, we begin with a parsimonious model that includes only measures of distance, fixed-location measures (e.g., climate), and state fixed effects, initially for the entire 1950-2000 period. This model not only mitigates multicollinearity, but also endogeneity because the explanatory variables are exogenous or predetermined. Next, market potential variables are added to form the base models. We then estimate models for a number of sub-periods both to assess robustness and to consider the evolution of the urban system as nonmetro areas become urban and small urban areas acquire previously nonmetro counties. Comparing the results over different time periods also allows us to assess how technological shocks to the mature urban hierarchy affect the role of distance and market potential, and hence the evolution of the hinterlands and small urban centers.

We then assess the sensitivity of our base findings to possible concerns with endogeneity, omitted autoregressive effects, as well as possible omitted variable bias and multicollinearity. Our key findings regarding the influence of urban hierarchy distances and market potential on core-periphery population dynamics are not altered either by the sub-period estimations or by the extensive sensitivity analysis.

3.1 Dependent Variable

The dependent variable is the percentage change in population between periods 0 and *t*.[6] We begin

[6]Following the U.S. Bureau of Economic Analysis, independent cities are merged with the surrounding county to

the analysis for the period of 1950 to 2000, and then consider the 1970-2000, 1980-2000, and 1990-2000 periods to assess the stability or evolution of the urban system over time. The sample of over 3,000 U.S. counties (excluding Alaska and Hawaii) is divided into various definitions of 'hinterland' and 'small urban' counties depending on the year and metropolitan status.[7] The sub-samples represent county types with expected differences in growth dynamics. If pooled into one sample, the likely heterogeneities between rural areas and higher-tiered urban areas would be hidden.

3.2 Defining the Hinterlands and Small Urban

We define 5 alternative samples, 3 versions of hinterlands and 2 of small urban areas. The three versions of hinterlands are: 1) Rural, the most restrictive definition that includes the approximately 1,300 rural counties (based on 2003 U.S. Census definitions) that never achieved urban status during the sample period; 2) NM-R, which is somewhat less restrictive, adds the micropolitan area counties, coinciding with the traditional nonmetropolitan (NM) definition; and 3) NM-I, the most inclusive version, based on the first U.S. government MA classification from 1950, which includes the 422 counties that were subsequently assigned to MAs that already existed in 1950 and the 362 counties that were assigned to newly designated MAs created after 1950.[8]

The two versions of small urban areas are: 1) Small MA-R, which includes counties in small MAs of less than 250 thousand in 1990 based on the 2003 MA definition, representing counties that were "small" through the entire sample period; and 2) Small MA-I, a more inclusive definition that adds 218 counties that were part of a small MA anytime during the sample period (even if their MA population is considerably greater today). The 250k division is selected because it is below the level that has been the focus of past agglomeration research and it represents about one-half of metropolitan counties.

3.3 Regression Specification

Except for the distance-based measures, most of the explanatory variables are drawn from the U.S. Census Bureau SF3 file (details provided in Appendix Table 1). In each sub-sample, for a given county *i*,

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form a more functional region (mostly in Virginia). Forty three mostly small rural counties are omitted due to the lack of economic data. See Partridge and Rickman (2006) for details of sample construction.

[7]Using 2003 definitions also allows us to use micropolitan areas in defining the most restrictive rural category, which were first defined in 2003. A micropolitan area is roughly defined as the counties that contain a city of between 10,000-50,000 or have tight commuting links. A MA is similarly defined for counties that surround a city of at least 50,000. See the Census Bureau definitions at www.census.gov/population/www/estimates/metrodef.html.

[8]We caution that the original 1950 MAs appear to have been defined on a more *ad hoc* basis than the more consistent metropolitan classification that evolved over time.

in state *s*, the most parsimonious population change equation is:[9]

(9) $\%\Delta POP_{ist-0} = \alpha + \varphi GEOG_{ist-1} + \gamma AMENITY_{is} + \sigma_s + \varepsilon_{ist}$,

where population growth is measured between periods 0 and *t.* The **GEOG** vector contains variables measuring distances to different tiers in the urban hierarchy and lagged market potential variables; the **AMENITY** vector contains natural amenities; and the state fixed effects σ_s account for common factors within a state. The regression coefficients are α, φ, and γ; and ε is the residual.

The initial set of spatial measures in **GEOG** reflects proximity to urban areas which are differentiated by their position in the urban hierarchy. The first is distance to the nearest MA of *any* size and its square—measured in kilometers. For a NM county, the distance is measured from the (population-weighted) center of the county to the center of the nearest MA. For a county that is part of a Small MA, this distance is from the population-weighted center of the county to the population-weighted center of its own MA. [10,11]

When examining the inclusive nonmetropolitan (NM-I) sub-sample for periods beginning after 1950 (e.g., 1970-2000), we include an indicator variable for counties that joined a MA between 1950 and the beginning of the sample period (e.g., 1970), as well as two corresponding interactions with distance and squared distance to their own MA. They account for the possibility of different distance dynamics compared with the other NM counties. In the inclusive small MA sample (Small MA-I), we control for counties that began the sample period as NM to allow for possible factors such as an 'adverse' remoteness distance penalty when these counties were more 'rural.' This contrasts with being more influenced by sprawl, where outlying suburban counties grow faster, which more likely would occur *after* they become part of the MA.

Beyond the distance to the nearest (or own) MA of any size, we include incremental distances to 3 more populous higher-tiered urban centers as shown in Equation 8.[12,13] These reflect the (net) marginal

[9]Using growth rates also has the advantage of differencing out any fixed effects associated with levels or the scale of the locality (Hanson, 2001). For example, some geographical places are more (less) productive due to ease of transportation etc. These places would have a fixed effect associated with a large (small) population level. Consistent with how using growth rates differences out population level fixed effects, Gibrat's law suggests that in equilibrium, all places should grow approximately equally regardless of initial size, which is a pattern that is strongly supported by the empirical evidence (Eeckhout, 2004). Of course, Gibrat's law and related empirical tests did not consider the effects of distance, only average effects.

[10]In a one-county MA, this distance is zero. We use 1990 MA population in assigning the particular tiers. When we employ MA definitions from 1973 and 1983, the hierarchy tier sizes are respectively derived using 1970 and 1980 populations. For population size, we use initial year population. Using a definition based on 2000 population when using the 2003 definition, did not strongly affect the results.

[11]*Within* a small MA, the influence of greater distances to the core would reflect the offsetting effects of concentration, sprawl, or commuting distances, which together suggest nonlinear effects. Although we control for within-MA effects, our focus is *inter*-urban effects, not the *intra* (within) urban area distance to own core effects.

[12]Using actual distances in place of incremental distance produces coefficients which are jointly significant though the individual coefficients are measured less precisely. This is not surprising because these measures have much more multicollinearity. More importantly, incremental distances capture our theoretical notion of a *marginal*

penalties for distance from productivity and amenity effects of each higher-tiered (or larger) urban center. We include the incremental distance segments from the county to reach a MA of at least 250k residents, at least 500k, and at least 1.5 million (we consider within-segment nonlinearity in section 4.4).[14,15] The 1.5 million category reflects national and major region centers, the 500k-1.5 million category reflects sub-region tiers, and the smaller-sizes are lower-tier centers. Consistent with a stable mature urban system, we assume these distances are predetermined (see Tabuchi and Thisse, 2006 for justification in a NEG setting).

The sum of the (incremental) distances is the distance to a MA of at least 1.5 million in 1990—i.e., we are measuring the total cost of reaching the nearest *highest* tiered city as shown in Figure 1. If distances do not accurately reflect travel time, measurement error would bias the distance coefficients towards zero, which works against finding any distance effects.[16]

GEOG also includes lagged population density as a measure of the county's level of agglomeration economies. If the county is part of a defined MA in the initial year, we include its total MA population; for counties not in a defined MA, population of the *nearest* MA is used. Finally, county size (square miles) is included to reflect space for residential housing, but also greater distance *within* the county to reach services, customers, and amenities, which may affect *within* county agglomeration spillovers.

Following Hanson (2005), market potential is measured by calculating U.S. Bureau of Economic Analysis (BEA) personal income (in '000$) in surrounding 0-100, 100-200, 200-300, 300-400, and 400-500 km rings measured from the population-weighted center of the county.[17] We use measures that predate the sample period by one year to mitigate possible endogeneity.[18] The market potential variables

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or incremental cost to reach a next higher-tiered city.

[13]If NM county A is 60kms from the nearest MA (which happens to be small) and 125kms from the nearest MA of at least 250k residents, the incremental distance to the nearest MA would be 65kms. For a county already located in a MA, the incremental value to reach an MA of any size is 0.

[14]Incremental distance is calculated as before. If a NM county is already nearest to a MA that is either larger than or equal to its own size category, then the incremental value is zero. For example, if the NM county's nearest MA is already over 250k people and 40kms away, then the nearest urban center is 40kms away and the incremental distance value for nearest MA> 250k equals zero. As another example, suppose rural county A is 30kms from its nearest MA, 120kms from a MA >250k people (say 300k population), 220kms from a MA >500k (which happens to be 2 million). Then the incremental distances are 30kms to the nearest MA, 90 incremental kms to the nearest MA>250k (120-30), 100 incremental kms to a MA >500k (220-120), and 0 incremental kms to a MA >1.5million.

[15]An additional variable, representing an even higher tier, the incremental distance to New York City, Chicago, or Los Angeles, whichever is closest, was almost always insignificant, and hence omitted from the final models.

[16]With the developed U.S. road system, the distance terms should accurately proxy for travel time. For example, Combes and Lafourcade (2005) find that the correlation between distances and French transport costs is 0.97.

[17]A county's income is included in a ring if its own population-weighted centroid falls into that ring. A 500km limit is chosen following Hanson's (2005, p. 20) finding that the effects of market potential shocks do not extend much beyond 400km. We could inversely weight nearby county income by the distance from the county of interest, but the current approach is more flexible because we do not have to find an optimal weighting scheme.

[18]There is a possibility that there is an omitted factor or shock that contemporaneously increases income and

capture more continuous effects of agglomeration, unlike the discrete changes that can occur with the urban-tier distances where small geographical movements may switch the most proximate urban centers.

While market potential and proximity in the urban system can produce similar responses, two distinct hypotheses regarding agglomeration spillovers are being appraised. Consider the following two cases that assume equal overall regional populations. In the first, there are ten cities of 150,000 people located on a 50km ring surrounding the county (and no other nearby urban centers). In the second, there is one city of 1.5 million located 50kms away (and no other nearby urban center). All else equal, the market potential is the same in both cases. However, the first case leads to the nearest urban center of any size being 50kms away, but it is farther to reach an urban center of at least 1.5 million. In the second case, it is 50kms to reach an urban area of at least 1.5 million, giving the county an advantage over the first case.

Other variables account for potential causes of labor supply (household) shifts as well as location-specific factors that may affect firm profitability (see Appendix Table 1)—i.e., independent of the urban agglomeration effects. First, natural **AMENITIES** are captured by four climate variables, a 1 to 24 scale variable measuring topography, percent water area, and three indicators for being within 50kms of the Pacific or Atlantic Oceans, and the Great Lakes. State fixed effects are added to account for factors such as settlement period, policy differences, or natural resources. With state fixed effects, the other regression coefficients are interpreted as the average response for a *within*-state change in the explanatory variables.

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 general forms of cross-sectional spillovers or spatial autocorrelation (Conley, 1999; Rappaport, 2007).[19]

4. EMPIRICAL RESULTS

4.1 Descriptive Trends

Descriptive statistics are reported in Table 1 for the full sample and for selected sub-samples. Column

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population in both the county and broad region, which creates a positive endogeneity bias. Using market potential from a year that precedes the period that population growth is measured avoids such direct endogeneity. In sensitivity analysis, we also omitted personal income within 100km of the county of interest because it may introduce a positive endogeneity bias if there are autocorrelated processes that link past income growth to future population growth (not shown). For example, many NEG studies remove the own region or the own country in calculating market potential to mitigate this concern (Redding and Venables, 2004; Head and Mayer, 2006; Knaap, 2006). Yet, the results were not affected by omitting this variable with the exception that our distance results became modestly stronger for all samples and the market potential effects are modestly stronger for the NM-I sample only.

[19] The bandwidth is 200kms, after which we follow convention and assume no correlation in county residuals.

(1) of Table 1 shows the descriptive statistics for the narrowly defined Rural sub-sample, column (2) for the NM-R sub-sample, and column (3) the inclusive NM-I sub-sample. Columns (4) and (5) contain the Small MA-R and the Small MA-I (see Section 3.2 above for more detail).

Table 1 shows the expected pattern over the 1950-2000, 1950-1970, 1970-2000, 1980-2000, and 1990-2000 periods. The most restrictive definition of hinterlands—Rural—had the lowest growth rates over the full period as well as during all sub-periods, followed by the NM-R and NM-I groups. Over this 50-year period, Rural and NM-R gained only about 12 and 32% population on average compared to almost 80% growth for the inclusive NM-I group. Across all three cases, these hinterland counties fared relatively worse in terms of growth in the 1950-1970 period. Among the 'winner' NM counties, population in both the 422 counties that were added to existing MAs and in the 362 counties that were added to newly created MAs roughly tripled on average (not shown). The two Small MA groups grew about 120-140% on average.

4.2 Base Regression Models

Table 2 shows the urban hierarchy regression results for the various sub-samples for the principal 1950-2000 period. Whether considering the distance variables individually or jointly, the results indicate that proximity in the urban hierarchy strongly affects population growth. For example, for the Rural sample, the linear influence of every kilometer farther away from the nearest MA is associated with 0.69% less population growth over the 1950-2000 period. The positive coefficient on the quadratic distance term is statistically significant. The linear and quadratic terms combined suggest that the negative population growth effects of distance dominate until 228kms. A Rural county located 100kms from a MA is expected to have grown 54% less during the period than an otherwise equal county immediately adjacent to the MA core. This negative effect increases to 77% at 200kms but declines to 71% by 300kms. Rural counties also are significantly and negatively affected by incremental distances to higher-tiered metropolitan areas.

When comparing across the three hinterland samples, the Rural sample tends to have smaller marginal distance penalties than the NM-R sample, which in turn are smaller than the more inclusive NM-I sample. In fact, when examining the two sub-samples of counties that shifted from NM to MA status over the ensuing 53 years, the counties that eventually became metropolitan experienced even greater marginal distance effects (not shown). Perhaps greater frequency of contacts with economic agents in the nearby MA increased the distance costs for counties with emerging linkages to their future MA.

For small MA counties, neither Small MA-R nor Small MA-I, exhibit a clear link between population growth and distance to the center of its own MA (or the MA it joined between 1950 and 2003). However, distances from its most proximate *higher*-tiered MAs appear to have large negative marginal impacts on small MA population growth. These higher-tiered marginal effects are larger than the results for the three NM sub-samples. It may be that in emerging metro counties and in existing small MAs, a service-intensive industry composition has tighter links to higher-tiered MAs in terms of customer markets and input-output linkages versus a more natural-resource orientation in rural areas. In any case, there are no apparent (NEG-style) growth shadows for small MAs in terms of being too close to larger urban tiers.

Population of the nearest MA is insignificant in the Rural and NM-R samples, suggesting that distance to a higher tier center in the urban hierarchy is more important than marginal changes in population of the higher tier area. Initial own population density is consistently inversely related to subsequent growth. The results for the other variables (not shown) are generally as expected. Favorable climate and household amenity attractiveness is associated with greater growth.

One concern associated with considering the entire 50 year period is that it may obscure the changing roles of transportation cost declines and IT technological advances that may have altered the importance of agglomeration and the frequency of contact among economic agents. For example, if the *dominant* factor is the decline of transportation and communication costs, the costs of distance would be strongest in the first-half of the sample period. Another concern with the 1950-2000 results is that they do not include NEG market potential variables, which may be correlated with the urban hierarchy distance variables. Since the initial level of personal income, our measure of market potential, is not available until 1969, it could not be included in the 1950-2000 population growth equation without incurring potential statistical endogeneity. For the 1970-2000 period, the first period our market potential variables *are* available, we first estimated regressions without market potential variables (shown in the first panel of Table 3) with results analogous to those in Table 2. The model reported in the second panel of Table 3 includes the 1969 market potential measures, becoming the base model for periods beginning in 1970 or later.

The results in Table 3 reveal that the coefficients for the urban hierarchy distance variables only slightly decrease in magnitude and statistical significance when the market potential measures are included—i.e., the urban hierarchy distance results are unaffected by the role of market potential. Population growth is inversely related to distance to higher-tiers of the urban hierarchy across all of the 'hinterland' models. Thus, the distance results do not appear to be artifacts of a particular period that contains idiosyncratic shocks. Regarding market potential, there is more of a mixed pattern, suggesting that many NEG-type models are less important in a mature urban system. Greater market potential within 100kms is generally statistically significant and the other measures are more likely insignificant. In the NM-I sample, market potential is even negative and significant in a couple of cases. Jointly, the market potential measures are statistically significant in two of the three NM samples, but are insignificant in both small MA samples.

4.3 The Urban Hierarchy's Impact on Hinterlands Population Growth over Time

We now more directly evaluate whether the technological shocks to the mature urban hierarchy are altering the strength of rural-urban interactions. First, using the estimated coefficients for five time periods, and five samples, together with mean actual distances, we sum the respective distance penalties for all of the individual incremental distance coefficients that are significant at the 10% level. Panels A to E of Table 4 respectively report these distance penalties for the following periods: 1950-2000, 1950-1970, 1970-2000, 1980-2000, and 1990-2000, in which up to 10 separate models are specified for each period. The base model is presented as model (1), with sensitivity results that follow below. We then do the same for the market potential variables that are significant at the 10% level, reported in Panels A through C of Table 5, for only the latter 3 periods due to data availability for market potential.

Model (1) in Panel A of Table 4 shows that over the 1950-2000 period, the typical NM county is severely penalized for remoteness from higher-tiered urban areas. At the mean distance from the various tiers of the urban hierarchy, the typical Rural county is estimated to experience 73% less growth than a Rural county that is adjacent to a MA core (i.e., 2.6% less growth on an annual basis, all else equal). For the other two hinterland samples, the distance penalties are even larger for the NM-R sample and especially for the most inclusive NM-I sample, with penalties ranging from ranging from 97% to 249%. Yet, in all cases, when comparing the results to Table 1, the distance penalty equals about one standard deviation change in actual population growth (i.e., growth is more variable in the more inclusive NM-I category).

For the two small MA specifications, over the 1950-2000 period, the estimates in Panel A suggest distance penalties of 100% to 129% for counties that started as MAs in 1950 for the Small MA-R and MA-I samples respectively. For counties that start out in 1950 as NM, the distance penalties are somewhat larger, ranging from 118% - 150%. Although comparable in size to the restrictive NM-R sample results, they are *relatively* less consequential, representing only about one-half of a standard deviation of their 50-year growth rates. For all three hinterland samples, access to successively higher-order producer and consumer goods and services (agglomeration economies) in the higher-tiered centers of the mature American urban hierarchy appears to be major drivers of their population growth. As an additional distinction, finding that the hinterlands are strongly influenced by proximity in the urban hierarchy somewhat differs from what others have found for the highest-order cities (e.g., Ioannides and Overman, 2004).

Although most of the past literature has considered the role of factors such as market potential, technological change in the natural resource sector, and amenities as driving rural population change, our research suggests an enormous role is played by proximity within the urban system. For example, even as households have increasingly migrated to Sunbelt states, these results suggest that population is also redistributing itself to be *nearer* to, if not exactly *in*, larger urban centers. Because most of the past focus has been on what has been happening *within* larger MAs or on patterns related to amenities, the trend of what has been happening in the regions surrounding medium and big urban centers has largely been overlooked.

Model (1) in Panels B through E of Table 4 shows the base model distance penalties for different periods to gauge the robustness of these findings over time and over the evolving redefinition of hinterland counties from nonmetro to metro and from small to large MA. This allows us to assess how interactions between the mature urban system and the hinterlands shifted as the system was subjected to various shocks. While the distance penalties reveal a similar pattern across all of the sub-periods, they appear to increase in later periods. For example, the Rural and NM-R penalties are almost as large in the shorter 10-year 1990-2000 as in the 20-year 1950-1970 period. A larger distance penalty in the latter periods is even more apparent in the small MA sample. Only for the most inclusive NM-I sample (with *initial period nonmetro counties* included) are the 1950-1970 distance penalties modestly larger than those for 1980-2000. The consistently strong distance penalties over sub-periods confirm that even when the metro-nometro designation is flexible in allowing the reflection of marginal changes in the urban system, distances from tiers of the urban system remain major determinants of hinterland population growth.

These results question the notion that innovations in communications and transportation technology signify that "distance is dead" (Cairncross, 1995, 1997) or that the "world is flat" (Friedman, 2005), at least in the spaces between the largest urban tiers. Overlooked by such pronouncements is that industry structure is now less reliant on natural resource sectors and goods production, even though the latter sector is dispersing to hinterland locations. Because access to natural resources was relatively more important in past eras, remoteness from cities was relatively less debilitative to a location with a strong natural resource economic base. Improved auto travel has made commuting more feasible and new IT likely has increased the frequency of interactions (Glaeser and Kohlhase, 2004). Thus, access to urban areas, and their agglomeration benefits, becomes a more important determinant of the hinterlands' economic base. For more remote small urban centers, technological change and related innovations may have made them even less competitive because the highest-order services in 'new economy' industries may be more concentrated in the highest-tiered centers than was the case for 'old economy' industries. These results are consistent with predictions from alternative models that suggest that new technologies and technological innovations would increase the value of particular types of agglomeration economies, further increasing the benefits of having access to the highest-tiered urban centers (Duranton and Puga, 2001; Desmet and Rossi-Hansberg, 2007).[20]

The influence of market potential when measured at the mean levels are reported Table 5. Model (1) in Panel A shows the base estimates, in which only estimates for periods that start in 1970 or later are reported due to the availability of the market potential variables. Taking the longest 1970-2000 period, in three of the five cases, market potential is positively related to population change, with exceptions being the NM-I and NM-R samples. In the three positive cases, market potential is associated with 6% to 12% higher population growth over the period when measured at their mean population values. There are similar patterns for the 1980-2000 and 1990-2000 periods reported in model (1) of Panels B and C. Thus, market potential has a relatively small positive association with population growth when compared to the distance penalties in Table 4. These results suggest that the spatial distribution of income/population matters—i.e., it is not just access to customers or suppliers without regard to how they are distributed. Thus, other factors do a better job of explaining the hinterland's spatial interactions in the urban system than pure market potential.

4.4 Sensitivity Analysis and Other Specifications

Given the strength and novelty of the results, it is especially important to consider potential limitations.

[20]Note that these alternative hypotheses were not directly interested in the role of distance and location within a mature urban hierarchy. Rather, we are making logical extensions to their hypotheses in arguing that technological change implies that access to agglomeration economies would have differential effects over time. For example, Duranton and Puga (2001) were more concerned by the product cycle at higher tiers of the hierarchy, while Desmet and Rossi-Hansberg (2007) were more interested in how technological change had different effects depending on the initial size of the service and manufacturing sector across all county sizes (localization economies).

We conduct extensive sensitivity analysis to address potential problems such as underlying omitted autoregressive effects, endogeneity bias, or omitted disequilibrium economic effects.

4.4.1 Urban hierarchy distances versus market potential

To assess whether our results are sensitive to alternative specifications and hypotheses of the population growth process, Models (2) to (10) in Tables 4 and 5 report the impact of various specifications on the distance penalty and the market potential effects. Model (2) omits the market potential variables, while model (3) omits the distance measures from the base model. Focusing on Panels C to E of Table 4 (periods for which the market potential variables are available) and all panels of Table 5, both the distance penalties and the market potential benefits have larger predicted values when the other variable grouping is omitted. However, the market potential effects consistently remain considerably smaller in magnitude than the urban hierarchy distance penalties.

4.4.2 Omitted fixed effects or underlying autoregressive trends

Another possible concern is that omitted fixed effects or persistent autoregressive trends are causing the residual to be correlated with the explanatory variables, which could cause statistical bias. This possibility is appraised in four ways. First, we assess how the results are affected by omitting the lagged county population density and the population of the nearest/own MA variables. The underlying rationale of this re-specification is that the lagged population levels could be affected by an autoregressive process—producing a correlation with the residuals. Thus, omitting these two variables creates an even more parsimonious reduced form. However, as shown in models (4) of Tables 4 and 5, both the estimated distance penalty and market potential effects are virtually unaffected.

We next assess the possibility that persistent effects or autoregressive processes are impacting the results by employing even deeper 1969/1970 lags of the population and market potential variables in the 1980-2000 and 1990-2000 results. Lagging these variables up to 40 years during the sample period should be sufficiently long to capture any autoregressive process. Nevertheless, as shown in models (5) of Tables 4 and 5, the resulting estimates are very similar to the base results.

In a third test of whether omitted long-run autoregressive effects or omitted county fixed effects are impacting our results, we estimate specifications that respectively add lagged 1950-1970 and 1970-1980 population growth rates to the 1980-2000 and 1990-2000 models. If omitted persistent growth processes underlie our results, the coefficients on the lagged population growth variables should account for them.[21] Again, models (6) suggest that the urban hierarchy distance penalty and market potential effects are robust.

Our fourth assessment uses a two-step approach to assess whether long-term autoregressive or omitted county fixed effects are contaminating the cross-sectional results. In the first step, we estimate the following fixed effects model for the 5 decades running from 1950-1960 to 1990-2000:

(10) $\%\Delta POP_{ist} = \sigma_{is} + \tau_t + \nu_{ist}$,

where σ is a county fixed effect, τ is a decade fixed effect, and ν_{ist} is the residual. The county fixed effect should contain any long-run underlying persistent county effects including omitted effects not accounted for in the cross-sectional models (i.e., it is the average county-specific effect per decade). The second step is to estimate an auxiliary model with $\hat{\sigma}_{is}$ as the dependent variable in a regression that includes the distance variables, state fixed effects, and the amenity variables. The distance variable coefficients are used to calculate an average per-decade distance penalty. Including the 1969 market potential variable is problematic due to possible endogeneity over the 1950-2000 period. For comparability, we also report the market potential effects in Table 5 by replacing the distance variables with the 1969 market potential results in the auxiliary regression.

Regarding the auxiliary regression results, we first note that the R^2 statistic ranged from about .45 to .60, illustrating that a significant share of the persistent county fixed effect (trend) is associated with these variables (not shown). Model (7) in Tables 4 and 5 reports the estimated 50-year distance penalty and market potential effects from the auxiliary regression of the county fixed effects. It shows that when using the two-step approach, the 50 year distance penalties are quite similar to the base estimates for the hinterland models, though they are smaller for the small MA models. Nonetheless, these results support the contention that distance penalties are a key component in explaining differential county growth rates regardless of assumptions about fixed effects. Model (7) of Table 5 continues to suggest that market potential plays a much smaller role than distance.

4.4.3 Non-linear incremental distance effects and different MA definitions

Model (8) reports the results when quadratic terms for all of the incremental distance terms are added

[21]We further lag population growth term 10 more years to rule out the possibility of creating another endogeneity problem that may occur when including a lagged dependent variable from the immediate proceeding period if there is serial correlation. We assume such autocorrelation is more cyclical and does not surpass 10 years. Lagging the growth term 10 more years should still account for any persistent fixed effects or the autoregressive effects.

to the base model (not just for distance to the nearest/own MA). This assesses the potential impact of non-linearity in the distance responses. Yet, the results in model (8) have the same pattern as our base estimates.

We next re-estimate our base model using the U.S. Census Bureau MA definitions from 1983. This model appraises whether it matters if we use the distances and corresponding populations applying MA definitions from about the sample period mid-point. The past literature finds that the urban hierarchy is quite stable over time, especially at the top (Black and Henderson, 1999; Eeckhout, 2004). Thus, if the results are similar using distances based on 1983 definitions, this lends support to the general hypothesis that the urban hierarchy is stable. More importantly for our purposes, it would provide further evidence that the results are robust. Model (9) of Tables 4 and 5 shows that these results consistently indicate that the distance penalty and market potential are not significantly affected by employing 1983 metropolitan definitions. Likewise, (not shown) this is also the case when using 1973 MA definitions, especially for the NM results.[22]

4.4.4 Possible omitted demographic and human capital effects

Models of migration and population change have long included economic and demographic measures associated with migration reflecting changing economic conditions or demographic causes such as retirees (Glaeser et al., 1995). Excluding these factors could cause omitted variable bias, while the tradeoff is that their inclusion may produce (any) statistical endogeneity or multicollinearity. To examine the sensitivity of our results, we add to the base 1970-2000, 1980-2000, and 1990-2000 models (due to data availability) the following variables: the population in the county's surrounding U.S. BEA economic region; the county's initial period (1970, 1980, or 1990) unemployment rate; the initial-period unemployment rate in the surrounding BEA region; and the percentage of the county's population 25 years and older that are college/ high school graduates (see Appendix Table 1).[23] Note that we lag these variables to obtain predetermined variables. Yet, model (10) of Tables 4 and 5 indicates that both the urban hierarchy distance penalties and the market potential results are robust to including these variables.

4.4.5 Section summary

This extensive sensitivity analysis reveals that our findings about the size and relative magnitudes of

[22]Regardless of the period, 1950-2000, 1950-70, etc., using the 2003 MA definitions to define distance terms almost always produced a little higher R^2 than distances from either the 1973 or 1983 definitions (not shown). This is true even for the 1950 to 1970 sample, 33 to 53 years before the 2003 MA definitions. Still, the incremental distances are not very different across the time periods, consistent with a stable hierarchy. For example, the simple correlations of the 2003 and 1983 MA definition distances, across the five urban tiers, ranges from .87 to .96.

[23]The surrounding BEA region variables are calculated as the average of the region ***net*** of the county in question. The U.S. BEA economic regions are 177 *functional* economic areas constructed from proximate counties.

our base estimates are robust to numerous possible concerns. These concerns include possible omitted variables, persistent trends that could introduce statistical endogeneity bias, additional nonlinearities, and sensitivity to differing definitions of the urban hierarchy.

5. SUMMARY AND CONCLUSIONS

We assessed the geographic reach of urban agglomeration economies in a mature urban system by examining modern population growth in U.S. hinterland and small urban counties. Novel features included accounting for both the county's market potential and its proximity to higher tiers of the urban hierarchy. We also considered multiple hinterland definitions and assessed whether the patterns changed over time.

Overall, we found that distance from agglomerated economic activity reduced area growth. The farther a county was from higher-tiered urban areas, the lower was its population growth, in which this effect was stronger than that of the county's proximity to overall market potential. Together, this suggests that standard NEG models should be augmented by alternative theories explaining spatial interactions for hinterland regions in a mature urban system (Tabuchi and Thisse, 2006). At the mean distances from the various tiers of the urban hierarchy, *ceteris paribus*, the typical rural county grew about 2.6% less per year over the 1950-2000 period than a rural county adjacent to a MA. So, although amenity attractiveness and the natural resource base of a county are important determinants of its growth, geographic proximity plays a strong role that seems much less noticed. One implication is that the hinterlands population is moving to be closer to the highest-tiered urban areas, though this is not the same as suggesting they are moving to be *within* these urban centers, consistent with a worldwide phenomenon identified by Henderson and Wang (2007). These results were robust over various time-periods that reflect evolving definitions of nonmetro and metro, as well as specifications that accounted for potential autoregressive effects, endogeneity, and omitted variables.

We also found that distance penalties on population growth are generally larger after 1970 than in previous decades. Thus, despite declines in transport costs, technological advances in communication, and the dispersion of manufacturing to low-cost locations, the economic costs of remoteness appear to be increasing. Consistent with the complex urban-system dynamics uncovered by Duranton (2007), all of this flux in the hinterlands occurred even as the higher tiers of the urban hierarchy remained stable. These findings support hypotheses that argue that recent technological advances make access to agglomeration economies even more important than in earlier periods. Possible explanations include an increased role of higher-end services in production and an urban bias in the availability of innovative technologies.

The primacy of access to tiers of the urban hierarchy in hinterland population growth elevates the importance of agglomeration economies (accessed across distance) for nonmetro economies. Where population growth and retention in hinterland areas is a policy objective, facilitating access to urban agglomeration is indicated, along with local job growth. Future research could try to unravel the sources of how new technologies and household preferences are affecting the economic costs of remoteness. Attempts could be made to identify these economic costs by assessing whether industry composition and distance to urban tiers implies differing input-output linkages as technologies change (e.g., see Ellison et al., 2007).

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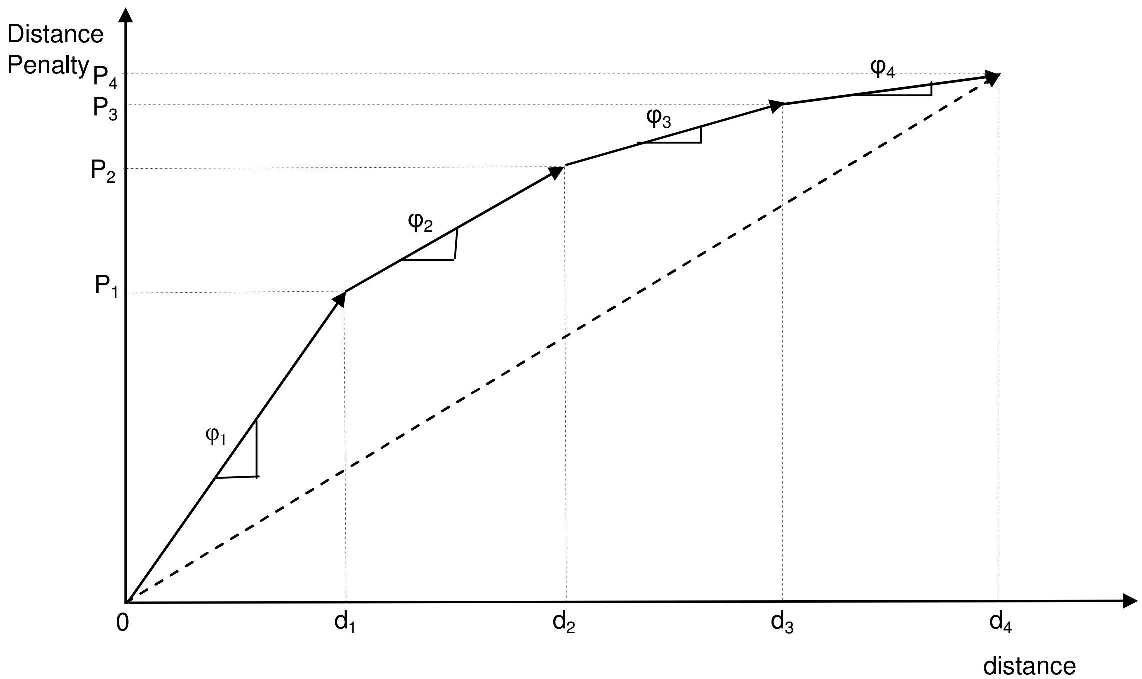
Figure 1: Representation of the Distance Penalties for a lower tiered center.



Note: The figure illustrates the distance penalty for a location *i* that is assumed to be at the lowest tier, four levels below the highest urban tier (or tier 4). Location *i* is situated distance d_1 from the next higher level (tier 1) center; distance d_2 from a tier 2 center (incremental distance $d_2 - d_1$); distance d_3 from tier 3 (incremental distance $d_3 - d_2$); and distance d_4 from tier 4 (incremental distance $d_4 - d_3$). These distances could be viewed as taken from a map, in which the higher-tiered cities could fall in any 360° direction from location *i*. These distances are then placed on the horizontal axis. The φ terms show the respective marginal penalties to access the successively higher levels of services, where for simplicity, the figure shows marginal penalties declining with successively higher urban tiers. The P terms reflect various levels of distance penalties with P_4 representing the cumulative penalty. Thus, the figure shows the nonlinear and discrete nature of distance effects in the urban hierarchy and the intervening effects of more proximate higher-tiered urban areas that are below the highest tier.

Table 1: Descriptive Statistics of Sub-samples over Different Time Periods

Variables	Rural	NM-R	NM-I	Small MA-R	Small MA-I	Full sample
Pop change (%)						
1950-00	11.55	32.2	79.47	122.47	138	84.6
	(67.83)	(122.93)	(230.45)	(271.64)	(257.38)	(227.85)
1950-70	-8.84	-0.81	11.5	30.06	35.9	16.36
	(23.35)	(30.68)	(51.00)	(54.01)	(62.29)	(56.11)
1970-00	18.05	25.48	43.82	57.57	63.03	42.64
	(44.43)	(59.36)	(86.78)	(72.08)	(76.28)	(84.04)
1980-00	4.43	8.36	17.83	27.51	30.69	17.79
	(24.17)	(27.73)	(37.93)	(35.24)	(36.7)	(36.95)
1990-00	6.16	7.54	11.43	15.64	16.83	11.22
	(13.45)	(13.49)	(16.43)	(15.18)	(15.44)	(16)
Distance (in km)						
Dist to the nearest MA03	103.29	96.43	77.11	n.a.	n.a.	n.a.
	(61.43)	(58.12)	(58.95)			
Dist to center of own MA03	n.a.	n.a.	n.a.	17.77	20.29	n.a.
				(18.47)	(18.45)	
Inc dist to MA03>250k	82.6	72.72	65.81	102.27	66.71	61.55
	(119.5)	(110.11)	(103.17)	(92.05)	(88.85)	(100.83)
Inc dist to MA03>500k	42.66	40.7	40.01	31.29	53.24	39.11
	(69.58)	(66.95)	(68.49)	(57.14)	(80.81)	(67.79)
Inc dist to MA03>1500k	92.52	99.27	103.8	93.33	112.12	101.47
	(110.28)	(114.66)	(120.62)	(118.97)	(135.12)	(121.63)
Dist to the nearest MA73	126.57	117.93	98.94	n.a.	n.a.	n.a.
	(82.00)	(77.72)	(76.69)			
Dist to center of own MA73	n.a.	n.a.	n.a.	59.34	47.79	n.a.
				(62.78)	(54.39)	
Inc dist to MA73>250k	70.41	62.02	55.87	68.05	56.66	52.93
	(102.93)	(95.38)	(91.09)	(89.27)	(87.67)	(89.43)
Inc dist to MA73>500k	47.25	47.04	45.07	35.93	57.46	44.58
	(74.42)	(74.20)	(73.76)	(67.03)	(84.88)	(74.56)
Inc dist to MA73>1500k	193.51	193.20	194.91	181.19	179.78	191.1
	(218.61)	(220.43)	(223.40)	(238.49)	(219.72)	(225.11)
Pop of nearest/own MA						
1950	268,102	275,016	335,909	393,002	313,516	431,181
	(317,733)	(307,619)	(555,240)	(666,856)	(549,830)	(1,058,341)
1970	319,200	332,837	407,241	380,882	358,403	481,632
	(419,092)	(417,142)	(533,193)	(593,594)	(486,956)	(760,512)
1990	255,095	278,550	389,768	138,268	269,621	559,037
	(369,520)	(412,584)	(634,339)	(45,484)	(339,331)	(1,407,861)
No. of counties	1,298	1,971	2,754	418	641	3,029

Notes: MA-R includes counties classified as part of 2003 MAs <250k based on 1990 pop. MA-I includes counties that are in MA-R sample **plus** counties that were part of 1950 MAs with ≤ 250,000 population but grew to become part of 2003 MAs with >250,000 population **plus** 1950 non-MA counties who were later assigned to MAs that had ≤ 250,000 population in 1950, but grew to become part of 2003 MAs with >250,000 population. For Rural and NonMA sample counties, 'Pop of nearest/own MA' refers to the 1950, 1970, or 1990 population of the nearest 1950 MA, 1973 MA, or 2003 MA respectively. For MA (2003) sample counties, it refers to the 1950, 1970, or 1990 population of their own 1950 MA, 1973 MA, or 2003 MA respectively, or their nearest MA in cases where the counties are part of 2003 MA, but were not part of an MA in the initial period.
R= "restrictive"; I= "inclusive".

Table 2: GMM Regressions of U.S. County Population Change 1950-2000 (%)

Variables	Rural	NM-R	NM-I	Small MA-R	Small MA-I
Intercept	525.15**	870.50**	895.42**	1723.18**	1500.89**
	(4.50)	(3.44)	(3.43)	(2.58)	(2.31)
Distance to nearest MA	-0.685**	-1.001**	-2.927**	n.a.	n.a.
	(-6.39)	(-5.02)	(-7.50)		
(Distance to nearest MA)^2	1.5E-3**	2.1E-3**	7.0E-3**	n.a.	n.a.
	(4.38)	(3.85)	(6.27)		
Distance to center of own MA	n.a.	n.a.	n.a.	2.022	-2.190
				(0.26)	(-0.79)
(Distance to center of own MA)^2	n.a.	n.a.	n.a.	-3.7E-2	8.2E-3
				(-0.19)	(0.14)
Inc dist to metro > 250,000 pop	-0.165**	-0.223**	-0.648**	-0.666*	-0.889**
	(-5.95)	(-4.44)	(-5.91)	(-1.89)	(-3.86)
Inc dist to metro > 500,000 pop	-0.107**	-0.252**	-0.617**	-0.601	-0.794**
	(-2.79)	(-3.09)	(-4.20)	(-1.41)	(-2.68)
Inc dist to metro > 1,500,000 pop	-0.060**	-0.051	-0.218**	-0.517**	-0.398*
	(-2.26)	(-1.29)	(-3.02)	(-2.56)	(-1.90)
Population density '50	-0.459**	-0.184**	-0.356**	-0.503**	-0.293**
	(-4.76)	(-2.14)	(-2.22)	(-2.89)	(-3.08)
Population of nearest/own MA '50	8.4E-6	3.1E-6	1.3E-5**	1.4E-5**	5.7E-6
	(1.41)	(0.41)	(2.27)	(2.02)	(0.81)
Weather/Amenity[a]	Y	Y	Y	Y	Y
State fixed effects (FE)	Y	Y	Y	Y	Y
Adjusted R^2	0.38	0.31	0.35	0.47	0.45
No. of counties	1297	1969	2752	418	641
F-statistic: All dist to MA = 0	15.74**	16.24**	67.29**	3.85**	8.49**
Inc distance to MA = 0	13.57**	12.99**	44.48**	6.24**	14.13**

Notes: Robust t-statistics from the Conley (1999) estimator are in the parentheses. A **or * indicates significant at ≤ 5% or ≤ 10% level respectively. Y=included. [a] Sunshine hours, January temp, July humidity, July temp, typography score, percent water area, proximity to Great Lakes, Pacific Ocean, and Atlantic Ocean, and county area (in sq. miles).

R= "restrictive"; I= "inclusive".

Table 3: GMM Regressions of U.S. County Population Change 1970-2000 (%)

Variables	Rural	NM-R	NM-I	Small MA-R	Small MA-I	Rural	NM-R	NM-I	Small MA-R	Small MA-I
Distance to nearest MA	-0.422**	-0.476**	-0.876**	n.a.	n.a.	-0.348**	-0.427**	-0.908**	n.a.	n.a.
	(-5.40)	(-5.16)	(-6.69)			(-4.47)	(-4.66)	(-6.56)		
(Distance to nearest MA)^2	9.1E-4**	1.0E-3**	2.0E-3**	n.a.	n.a.	7.8E-4**	9.0E-4**	2.1E-3**	n.a.	n.a.
	(3.91)	(3.79)	(5.58)			(3.43)	(3.51)	(5.62)		
Distance to center of own MA	n.a.	n.a.	n.a.	0.906	1.516*	n.a.	n.a.	n.a.	0.974	1.464*
				(0.60)	(1.87)				(0.64)	(1.84)
(Distance to center of own MA)^2	n.a.	n.a.	n.a.	-1.4E-2	-2.3E-2	n.a.	n.a.	n.a.	-1.6E-2	-2.6E-2
				(-0.33)	(-1.25)				(-0.39)	(-1.41)
Inc dist to metro > 250,000 pop	-0.133**	-0.151**	-0.219**	-0.224**	-0.294**	-0.112**	-0.137**	-0.233**	-0.233**	-0.278**
	(-5.83)	(-6.25)	(-6.09)	(-4.07)	(-4.35)	(-5.02)	(-5.36)	(-5.76)	(-4.11)	(-4.13)
Inc dist to metro > 500,000 pop	-0.091**	-0.133**	-0.179**	-0.229**	-0.199**	-0.074**	-0.123**	-0.189**	-0.238	-0.186**
	(-3.22)	(-3.50)	(-3.79)	(-2.98)	(-2.98)	(-2.72)	(-3.18)	(-3.79)	(-3.07)**	(-2.72)
Inc dist to metro > 1,500,000 pop	-0.041**	-0.021	-0.046**	-0.159**	-0.069	-0.027	-0.016	-0.058**	-0.164**	-0.058
	(-2.15)	(-1.04)	(-1.99)	(-3.11)	(-1.45)	(-1.42)	(-0.78)	(-2.20)	(-2.98)	(-1.19)
Personal income within 100 km radius, 1969	N	N	N	N	N	1.6E-03**	9.3E-04	5.0E-04**	-1.2E-04	9.2E-04**
						(2.25)	(1.25)	(1.98)	(-0.27)	(3.21)
Personal income within 100-200 km ring, 1969	N	N	N	N	N	3.1E-04**	1.2E-04	-3.6E-04	-2.0E-04	-1.0E-04
						(2.45)	(0.86)	(-1.54)	(-0.92)	(-0.58)
Personal income within 200-300 km ring, 1969	N	N	N	N	N	1.6E-05	-1.3E-05	-2.3E-04*	3.1E-04**	2.6E-04*
						(0.15)	(-0.12)	(-1.75)	(2.06)	(1.65)
Personal income within 300-400 km ring, 1969	N	N	N	N	N	1.6E-04*	8.5E-05	-1.7E-05	2.5E-04	3.9E-05
						(1.91)	(0.69)	(-0.12)	(1.35)	(0.22)
Personal income within 400-500 km ring, 1969	N	N	N	N	N	2.9E-05	-1.2E-04	-2.2E-04**	-4.3E-05	2.6E-05
						(0.38)	(-1.33)	(-2.09)	(-0.19)	(0.14)
Weather/Amenity[a]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
State fixed effects (FE)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.47	0.39	0.39	0.52	0.43	0.47	0.39	0.40	0.52	0.43
No. of counties	1297	1969	2752	418	641	1297	1969	2752	418	641
F-statistic: All dist to MA = 0	20.55**	21.97**	42.72**	7.37**	11.35**	10.91**	14.67**	40.57**	6.19**	8.59**
Inc distance to MA = 0	23.74**	24.26**	31.39**	10.35**	12.80**	14.32**	18.10**	30.91**	8.75**	10.37**

Notes: Robust t-statistics from the Conley (1999) estimator are in the parentheses. A **or * indicates significant at ≤ 5% or ≤ 10% level respectively. Y=included, N=not included. [a] Sunshine hours, January temp, July humidity, July temp, typography score, percent water area, proximity to Great Lakes, Pacific Ocean, and Atlantic Ocean, and county area (in sq. miles). All models further included an intercept, 1970 population density, and 1970 population of the nearest/own MA. R= "restrictive"; I= "inclusive".

Table 4: Urban Hierarchy Distance Penalties Evaluated at the Mean Distances

Panel A (1950-2000)

Models	Rural	NM-R	NM-I	Small MA-R County in '50 MA Yes	Small MA-R County in '50 MA No	Small MA-I County in '50 MA Yes	Small MA-I County in '50 MA No
(1)(2) Base = Dist to MA03	-72.96	-96.64	-249.49	-99.80	-118.24	-129.13	-149.72
(4) Base - density & nearest MA pop	-72.00	-93.96	-242.37	-100.06	-117.67	-125.89	-144.98
(7) Auxiliary FE model	-73.34	-68.42	-155.27	-39.57		-46.71	
(8) Base + sq incremental dist	-73.66	-102.12	-267.88	-111.23	-97.97	-97.89	-119.04
(9) Base83 (with dist to MA83)	-71.67	-95.15	-239.16	-79.70	-96.36	-127.72	-134.14

Panel B (1950-1970)

Models	Rural	NM-R	NM-I	Small MA-R County in '50 MA Yes	Small MA-R County in '50 MA No	Small MA-I County in '50 MA Yes	Small MA-I County in '50 MA No
(1)(2) Base = Dist to MA03	-15.47	-18.17	-46.76	-3.14	-7.25	-14.06	-16.16
(4) Base - density & nearest MA pop	-14.91	-19.65	-56.68	-3.19	-7.37	-15.01	-16.73
(8) Base + sq incremental dist	-15.53	-18.16	-46.07	-12.95	-11.96	-11.50	-19.12
(9) Base83 (with dist to MA83)	-17.69	-18.95	-50.48	-4.48	-7.83	-20.51	-21.61

Panel C (1970-2000)

Models	Rural	NM-R	NM-I County in '73 MA No	NM-I County in '73 MA Yes	Small MA-R County in '73 MA Yes	Small MA-R County in '73 MA No	Small MA-I County in '73 MA Yes	Small MA-I County in '73 MA No
(1)(5) Base = Dist to MA03+mkt pot.	-37.16	-44.72	-84.64	34.93	-45.60	-47.12	-27.00	-29.59
(2) Base - mkt potentials	-49.02	-49.56	-79.87	39.44	-43.97	-45.47	-28.71	-31.41
(4) Base – density & nearest MA pop	-35.93	-43.60	-89.28	41.12	-49.92	-51.95	-27.77	-29.55
(8) Base + sq incremental dist	-42.68	-53.53	-86.51	34.83	-44.33	-42.13	-37.30	-39.21
(9) Base83 (d. to MA83, '69 mkt pot.)	-35.15	-45.32	-81.88	0.91	-40.30	-37.51	-21.81	-18.61
(10) Base + Demog & Econ Vars	-38.25	-45.77	-81.84	38.14	-47.78	-49.67	-27.93	-30.54

Panel D (1980-2000)

Models	Rural	NM-R	NM-I County in '83 MA No	NM-I County in '83 MA Yes	Small MA-R County in '83 MA Yes	Small MA-R County in '83 MA No	Small MA-I County in '83 MA Yes	Small MA-I County in '83 MA No
(1) Base = Dist to MA03 + mkt pot.	-19.95	-21.79	-40.21	7.52	-22.04	-21.91	-15.40	-15.48
(2) Base - mkt potentials	-28.11	-26.46	-39.33	8.46	-23.74	-23.46	-16.24	-16.33
(4) Base - density & nearest MA pop	-19.60	-21.69	-39.79	10.15	-21.91	-21.72	-14.01	-13.97
(5) Base, with '69 mkt pot.,1970 pop	-23.27	-24.40	-41.50	5.55	-23.38	-23.20	-15.36	-15.50
(6) Base + 1950-70 pop growth	-18.44	-20.04	-36.50	7.38	-22.74	-22.44	-14.76	-14.88
(8) Base + sq incremental dist	-20.53	-21.51	-42.44	4.72	-24.84	-21.54	-20.79	-20.56
(9) Base83 (d. to MA83, '79 mkt pot.)	-18.04	-21.50	-42.04	2.02	-19.49	-17.10	-13.32	-10.45
(10) Base + Demog + Econ Vars	-22.80	-22.75	-35.41	8.16	-23.07	-22.80	-15.06	-15.15

Panel E (1990-2000)

Models	Rural	NM-R	NM-I County in '93 MA No	NM-I County in '93 MA Yes	Small MA-R County in '93 MA Yes	Small MA-R County in '93 MA No	Small MA-I County in '93 MA Yes	Small MA-I County in '93 MA No
(1) Base = Dist to MA03 + mkt pot.	-12.16	-11.31	-17.03	-3.27	-8.75	-8.77	-5.09	-5.36
(2) Base - mkt potentials	-16.45	-13.23	-17.15	-3.01	-10.00	-10.00	-5.58	-5.87
(4) Base - density & nearest MA pop	-11.32	-10.67	-17.56	-3.22	-8.41	-8.45	-4.70	-4.93
(5) Base, with '69 mkt pot., 1970 pop	-14.21	-13.00	-18.45	-4.48	-9.34	-9.40	-5.38	-5.71
(6) Base + 1970-80 pop growth	-9.24	-8.31	-11.67	-2.45	-3.98	-3.22	-2.35	-2.66
(8) Base + sq incremental dist	-10.77	-10.08	-17.72	-3.79	-12.43	-12.06	-10.42	-10.80
(9) Base83 (d. to MA83, '89 mkt pot.)	-10.84	-10.70	-16.26	-5.04	-7.35	-6.89	-3.94	-3.14
(10) Base + Demog. & Econ Vars.	-11.63	-10.47	-13.76	-3.10	-6.79	-6.07	-2.73	-3.09

Notes: Not all models can be estimated for every time period. If the model is not applicable, the row is simply omitted in the table. The NM-I sample includes a dummy variable indicating if a county switched to MA at the beginning of the relevant sample period (i.e., switched from non-MA to MA between 1950 and the start of the sample period), its interactions with the distance to **(cont)** nearest MA and its square. Small MA-R and -I samples include a dummy variable indicating if a county was designated as non-MA at the beginning of the relevant period—i.e., had not been officially denoted to be part of the MA—and interactions of this dummy with distance to the center of own MA and its square. All models use GMM to account for spatial error correlation. See the text for more details.

Model Details: (1) Base: includes distance to nearest MA for non-MA counties or center to the own MA for MA counties, its square, incremental distance to MA>250,000 pop, inc dist to MA>500,000 pop, inc dist to MA>1.5 mill pop, plus pop density and pop of the nearest or own MA at the beginning of the period, January sun hours and temp., July relative humidity and temp., typography score, % of county area in water, proximity to Great Lakes, Pacific Ocean, and Atlantic Ocean, state fixed effect dummies, plus 5 market potential variables defined as BEA personal incomes within 100 km radius, 100-200km, 200-300km, 300-400km and 400-500km rings, measured at the beginning of the period. The market potential variables are only added to the 1970-00, 1980-00 and 1990-00 models since they are not available before 1969. **(7)** The auxiliary fixed-effect model is available for only the 1950-00 period. It is estimated in two steps. First, for each county, population change for each of the five decades between 1950 and 2000 are pooled and regressed on an intercept, 4 decade fixed effects, and 3,028 county dummies. Then for each of the five different samples shown in the headings of the table, the county dummy coefficients are regressed on the 4 distance variables, amenity/weather variables, and state fixed effects. Because the county fixed effects are an average decade effect, they are raised to the 5^{th} power to account for the total estimated impact over the 5 decades. **(10)** Base + pop in surrounding BEA regions, median household income, and its surrounding measure, unemployment rate, and its surrounding measure, % high school grads, and % college grads, all measured at the beginning of the period.

R= “restrictive”; I= “inclusive”.

Table 5: Market Potential Effects Evaluated at the Mean Market Potential

	Panel A (1970-2000)							
	Rural	NM-R	NM-I		Small MA-R		Small MA-I	
Models			County in '73 MA		County in '73 MA		County in '73 MA	
			No	Yes	Yes	No	Yes	No
(1)(5) Base = Dist to MA03+mkt pot.	8.23	0.00	-7.64	-8.30	6.72	5.68	12.11	8.59
(3) Base - dist (to MA03)	14.72	8.54	4.34	10.97	19.07	14.94	17.67	12.66
(4) Base - density & nearest MA pop	7.62	0.00	-14.12	-19.88	9.50	8.03	0.00	0.00
(7) Auxiliary FE model (1950-2000)	19.87	16.69	17.79		18.30		6.70	
(8) Base + sq incremental dist	7.57	0.00	-12.87	-17.83	0.00	0.00	5.60	3.49
(9) Base83 (d. to MA83, '69 mkt pot.)	8.79	0.00	-8.99	-9.82	7.30	6.17	5.41	3.37
(10) Base + Demog + Econ Vars	7.64	0.00	-3.83	-6.06	0.00	0.00	11.93	8.53

	Panel B (1980-2000)							
	Rural	NM-R	NM-I		Small MA-R		Small MA-I	
Models			County in '83 MA		County in '83 MA		County in '83 MA	
			No	Yes	Yes	No	Yes	No
(1) Base = Dist to MA03 + mkt pot.	7.96	1.85	0.00	0.00	8.67	7.12	6.52	4.66
(3) Base - dist (to MA03)	11.61	8.57	2.85	8.35	28.05	21.95	11.88	8.10
(4) Base - density & nearest MA pop	7.73	1.97	0.00	0.00	8.59	7.06	4.32	3.52
(5) Base, with '69 mkt pot, 1970 pop	6.32	1.48	0.00	0.00	14.31	11.69	6.00	4.15
(6) Base + 1950-70 pop growth	7.13	1.93	0.00	0.00	7.99	6.57	6.29	4.55
(8) Base + sq incremental dist	7.96	1.83	0.00	0.00	14.49	12.18	4.16	3.39
(9) Base83 (d. to MA83, '79 mkt pot.)	8.33	1.82	-2.68	-3.27	8.71	7.16	7.03	4.96
(10) Base + Demog + Econ Vars	8.14	3.93	0.00	0.00	7.95	6.53	4.58	3.72

	Panel C (1990-2000)							
	Rural	NM-R	NM-I		Small MA-R		Small MA-I	
Models			County in '93 MA		County in '93 MA		County in '93 MA	
			No	Yes	Yes	No	Yes	No
(1) Base = Dist to MA03 + mkt pot.	1.47	0.77	0.00	0.00	3.02	2.54	1.36	0.65
(3) Base - dist (to MA03)	5.20	4.76	2.88	5.07	10.07	7.46	4.89	3.07
(4) Base - density & nearest MA pop	2.19	0.82	0.00	0.00	3.05	2.57	0.00	0.00
(5) Base, with '69 mkt pot. 1970 pop	1.58	0.00	0.00	0.00	2.40	1.95	0.99	0.45
(6) Base + 1950-70 pop growth	0.43	0.93	0.44	1.21	2.58	2.17	2.30	1.59
(8) Base + sq incremental dist	2.30	0.85	0.00	0.00	2.89	2.43	0.98	0.47
(9) Base83 (d. to MA83, '89 mkt pot.)	2.29	0.00	0.00	0.00	4.64	3.52	1.56	0.75
(10) Base + Demog + Econ Vars	1.14	0.00	-1.17	-2.19	-1.65	-0.97	0.00	0.00

Notes: Not all models can be estimated for every time period. If the model is not applicable, the row is omitted in the table. The NM-I sample includes a dummy variable indicating if a county switched to MA at the beginning of the relevant sample period (i.e., switched from non-MA to MA between 1950 and the start of the sample period), its interactions with the dist to nearest MA and its square. Small MA-R and -I samples include a dummy variable indicating if a county was designated as non-MA at the beginning of the relevant period—i.e., had not been officially denoted to be part of the MA—and interactions of this dummy with distance to the center of own MA and its square. All models use GMM to account for spatial error correlation. See the text for more details.
Model Details: **(1)** Base: includes distance to nearest MA for non-MA counties or center to the own MA for MA counties, its square, incremental distance to MA>250,000 pop, inc dist to MA>500,000 pop, inc dist to MA>1.5 mill pop, plus pop density and pop of the nearest or own MA at the beginning of the period, January sun hours and temp., July relative humidity and temp., typography score, % of county area in water, proximity to Great Lakes, Pacific Ocean, and Atlantic Ocean, state fixed effect dummies, plus 5 market potential variables defined as BEA personal incomes within 100 km radius, 100-200km, 200-300km, 300-400km and 400-500km rings, measured at the beginning of the period. The market potential variables are only added to the 1970-00, 1980-00 and 1990-00 models since they are not available before 1969. **(7)** The auxiliary fixed-effect model shown in Panel A is available for 1950-00 period. It is estimated in two steps. First, for each county, population change for each of the five decades between 1950 and 2000 are pooled and regressed on an intercept, 4 decade fixed effects, and 3,028 county dummies. Then for each of the five different samples shown in the headings of the table, the county dummy coefficients are regressed on the 5 market potential variables, amenity/weather variables, and state fixed effects. Because the county fixed effects are an average decade effect, they are raised to the 5^{th} power to account for the total estimated impact over the 5 decades. **(10)** Base + pop in surrounding BEA regions, median household income, and its surrounding measure, unemployment rate, and its surrounding measure, % high school grads, and % college grads, all measured at the beginning of the period.
R= "restrictive"; I= "inclusive".

Appendix Table 1: Variable Definitions and Descriptive Statistics

Variables	Description	Sources	1990 Mean (St. dev.)	1980 Mean (St. dev.)	1970 Mean (St. dev.)	1950 Mean (St. dev.)
Dist to nearest/own MA (kms)	Distance (in km) between centroid of a county and population weighted centroid of the nearest metropolitan area (MA), or the distance to the centroid of its own MA	Census Bureau, C-RERL, Authors' est.	71.24 (59.31)	81.11 (65.71)	90.85 (77.51)	119.16 (113.95)
Inc dist to metro>250k	Incremental distance (in km) to an MA with at least 250,000 population (see text for details)	Authors' est.	61.55 (100.83)	58.70 (101.26)	52.93 (89.43)	66.00 (88.53)
Inc dist to metro>500k	Incremental distance to an MA with at least 500,000 population (see text for details)	Authors' est.	39.11 (67.79)	43.78 (73.18)	44.58 (74.56)	70.62 (113.67)
Inc dist to metro>1500k	Incremental distance to an MA with at least 1,500,000 population (see text for details)	Authors' est.	101.47 (121.63)	106.48 (125.75)	191.10 (225.11)	361.25 (312.74)
Personal income in five 100km rings	Personal income within 0-100, 100-200, 200-300, 300-400, and 400-500 km radius ('000$)	BEA REIS, C-RERL	n.a.	n.a.	n.a.	n.a.
Population density	County population per square mile	1990 Census	207.83 (1,593.40)	197.79 (1,544.98)	197.31 (1,718.69)	175.66 (1,977.52)
Pop of nearest/own MA	Population of the nearest/own MA (see text for details)	Authors' est.	559,036.65 (1,407861.18)	617,494.46 (1,553,762.45)	481,631.50 (760,512.06)	431,180.88 (1,058,341.13)
Weather/Amenity						
Sun hours	Mean January sun hours	ERS, USDA	151.41 (33.21)	151.41 (33.21)	151.41 (33.21)	151.41 (33.21)
January temp	Mean January temperature (degree F)	ERS, USDA	32.95 (12.07)	32.95 (12.07)	32.95 (12.07)	32.95 (12.07)
July humidity	Mean July relative humidity (%)	ERS, USDA	56.15 (14.49)	56.15 (14.49)	56.15 (14.49)	56.15 (14.49)
July temp	Mean July temperature (degree F)	ERS, USDA	75.89 (5.35)	75.89 (5.35)	75.89 (5.35)	75.89 (5.35)
Typography	Typography score 1 to 24, in which 24 represents the most mountainous terrain	ERS, USDA	8.83 (6.59)	8.83 (6.59)	8.83 (6.59)	8.83 (6.59)
Percent Water	Percent of county covered by water	ERS, USDA	4.61 (11.29)	4.61 (11.29)	4.61 (11.29)	4.61 (11.29)
Proximity to Great Lakes	1 if county centroid is within 50km of Great Lakes	Authors' est	0.04 (0.19)	0.04 (0.19)	0.04 (0.19)	0.04 (0.19)
Proximity to Pacific Ocean	1 if county centroid is within 50km of Pacific Ocean	Authors' est	0.02 (0.13)	0.02 (0.13)	0.02 (0.13)	0.02 (0.13)
Proximity to Atlantic Ocean	1 if county centroid is within 50km of Atlantic Ocean	Authors' est	0.08 (0.28)	0.08 (0.28)	0.08 (0.28)	0.08 (0.28)
Economic/Demographic						
Median HH inc	Median household income ($)	Census Bureau, Geolytics Inc.	23,842.7 (6,388.8)	14,248.49 (3,286.26)	7,476.86 (1,857.28)	n.a.

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 employment shares in each sector	BEA, REIS, Authors' est.	0.16 (0.04)	n.a.	n.a.	n.a.
Unemployment rate	Civilian unemployment rate (%)	Census Bureau, Geolytics Inc.	6.67 (3.02)	6.81 (3.29)	4.53 (2.29)	n.a.
Agriculture share	1990 Percent employed in agriculture sector	1990 Census	8.45 (8.20)	n.a.	n.a.	n.a.
Goods share	1990 Percent employed in (nonfarm) goods sector	1990 Census	27.28 (10.19)	n.a.	n.a.	n.a.
Percent pop by age group	Percent of 1990 population in each age cohort	1990 Census	n.a.	n.a.	n.a.	n.a.
Percent high school	Percent of population 25 years and over that have completed high school	Census Bureau, Geolytics Inc.	34.36 (6.12)	59.23 (12.27)	44.62 (12.67)	n.a.
Percent college graduate	Percent of population 25 years and over that are 4-year college graduates	Census Bureau, Geolytics Inc.	13.43 (6.45)	11.38 (5.30)	7.28 (3.93)	n.a.
Surrounding Variables						
Population_surr	Weighted average population in surrounding counties within a BEA region[a]	Authors' est.	2,002,891.29 (2,858,592.48)	1,837,765.97 (2,642,033.03)	1,673,266.33 (2,603,983.29)	n.a.
Median HH inc_surr	Weighted average median household income in surrounding counties within a BEA region[a]	Authors' est.	26,753.7 (4,795.7)	15,749.30 (2,263.30)	8,517.46 (1,440.08)	n.a.
Industry mix gr_surr	Weighted average industry mix employment growth in surrounding counties within a BEA region[a]	Authors' est.	0.19 (0.02)	n.a.	n.a.	n.a.
Unemployment rate_surr	Weighted average total civilian unemployment rate in surrounding counties within a BEA region[a]	Authors' est.	6.25 (1.55)	6.33 (2.00)	4.37 (1.26)	n.a.
State fixed effects (FE)	Dummy variables		n.a.	n.a.	n.a.	n.a.
No. of counties			3,029	3,029	3,027	3,027

Notes: Centroids are population weighted. The metropolitan/micropolitan definitions follow from the 2003 definitions. BEA REIS= Bureau of Economic Analysis, Regional Economic Information System; ERS, USDA = Economic Research Services, U.S. Department of Agriculture; C-RERL = Canada Rural Economy Research Lab, University of Saskatchewan.

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.