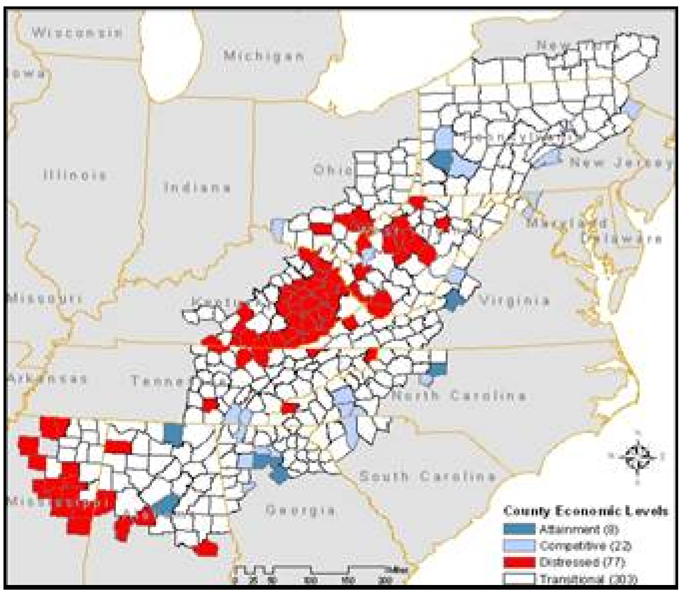
Sources of Regional Growth in Non-Metro Appalachia

Vol. 3 Statistical Studies of Spatial Economic Relationships



Prepared for the Appalachian Regional Commission

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SOURCES OF GROWTH PROJECT

The *Sources of Growth* project is part of a series of research efforts funded by the Appalachian Regional Commission to improve our understanding of factors affecting economic growth in rural and distressed areas. As stated in the Volume 1 Introduction, "the starting premise of this project is that there can multiple paths that an area can pursue in successfully enhancing job and income creation. They may build on natural resources, cultural resources, human resources, local amenities, institutional facilities or location advantages. The resulting direction of economic growth may involve manufacturing or supply chain development, resource extraction or tourism development, educational development or trade center development." This research is intended to provide a basis of information that can ultimately be useful for enhancing the effectiveness of policies and tools aimed at improving the region's economic development.

This is Volume 3 in a series of reports prepared as part of this project:

- ***Executive Summary*** –synthesis of findings from all work products related to the study's four main research components.

- ***Volume 1, Project Background and Prior Research on Economic Growth Paths*** – study objectives, characteristics of non-metro Appalachian counties, classification of economic development growth paths, and a synopsis of white paper findings on theory relating to economic development growth paths.

- ***Volume 2, Case Studies of Local Economic Development Growth Processes*** – findings related to growth paths as observed for selected case studies covering manufacturing industry specialization clusters, supply chain-based development, tourism-based development, advanced technology development, and diversification from resource-based economies.

- ***Volume 3, Statistical Studies of Spatial Economic Relationships*** – findings from a series of econometric modeling and GIS-based analyses, focusing on roles of spatial adjacency, market access and transportation in determining economic growth and development of trade centers.

- ***Volume 4, Tools for Economic Development & Study Conclusions***– description of new and updated tools available to ARC and its Local Development Districts to assess economic development opportunities and potential directions for economic growth.

- ***Appendices*** – (A) Spatial Analysis of Economic Health, (B) Economic Analysis of Hub-Spoke Relationships, (C) White Papers on Economic Growth Theories, (D) Literature Review of Empirical Studies on Spatial Influences in Economic Development.

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ACKNOWLEDGEMENTS

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The Sources of Growth project involved a team of researchers including:

- Economic Development Research Group, Inc. (EDRG) – Lisa Petraglia (Project Director), Glen Weisbrod and Teresa Lynch, with research support from Tyler Comings, Brett Piercy and Susan Moses;

- Regional Technology Strategies, Inc. (RTS) –Stuart Rosenfeld, Phil Psilos and Dan Broun;

- Massachusetts Institute of Technology, Department of Urban Studies & Planning (MIT-DUSP) – Prof. Karen R. Polenske, Prof. Joseph Ferreira, Jr., Ayman Ismail, and Li Xin, with research support from Tan Zhijun, and Isabelle Yi Xu.

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Finally, the project team acknowledges the important role of prior ARC-funded research studies by Andrew Isserman, Ed Feser and Oleg Smirnov that provided a foundation for this project to build upon.

1 INTRODUCTION

1.1 Background

Role in the Sources of Growth Project. Volume #3 presents results of four empirical research studies conducted as part of the Sources of Growth project. These studies build directly on the discussion of theory and prior research which are covered in Volume 1, and corroborate some of the case study findings of Volume 2.

The prior documents identified a consistent set of location and access factors that affect the economic viability and opportunity of various growth paths. They are summarized in Exhibit 1-1. Accordingly, all four of the empirical research studies presented here examine an aspect of the relationship between a county's spatial location or access characteristics and its pattern of economic growth and development. All four also utilize some form of econometric modeling and/or geographic information system to examine these relationships.

Exhibit 1-1. Location and Access Factors Affecting Economic Growth Paths

Basis for County's Economy Growth	Examples of Location and Access Factors
Trade Center	• Adjacency of rural markets (spokes) to micropolitan trade centers (hubs); • Scale of markets relative to regional population
Agglomeration (*e.g.* cluster economy)	• Labor force size • Delivery market reach
Supply-Chain (*e.g.* dispersal economy)	• Distance to highway, rail terminal, air or marine port • Same day delivery distance
Natural Amenity or Cultural Assets	• Access to visitor markets • Distance to highway
Knowledge (Learning) Assets	• Labor force or population size • Proximity to major education or technology institutions

The motivation for this research comes from three directions: (1) recognition that while the various paths of economic growth serve different markets, they all depend in some way on access; (2) the fact that many of ARC's programs aim to reduce isolation and improve access, and (3) the availability of relatively new analytic methods for examining spatial relationships among counties. This research thus aims to build upon prior ARC-funded research and to advance our understanding of how ARC investments promote economic development by reducing isolation and increasing local capacity for growth.

1.2 Study Summaries and their Foundations

Extending Prior Research. It is important to note how these research efforts build upon prior studies.

- The first study focuses on enhancing our understanding of relationships between counties that serve as rural trade centers (economic hubs) and adjacent counties that are served by them (economic spokes). This work by Ayman Ismail of MIT utilizes new economic base techniques first explored by Smirnov and Smirnova (See ““An Assessment of the Economic Base of Distressed and Near-Distressed Counties in Appalachia,” 2000) and revisits the evaluation of county-level “spatial regional multipliers” based on more recent employment data.

  The Pike County case study of Volume 2 can be better understood from the perspective of how well its economy ties into those of the four other counties in the Big Sandy Area (BSA) – all distressed counties. Pike County’s transitional status has been achieved through attempts to gradually diversify its mining economy, and through a unique public works project that removed barriers to development, and opened access options. The BSA counties of Maggofin and Martin exhibit the weakest *spatial regional multipliers* of the five counties, and all five counties have economic compositions that tend to hinder each in benefiting from growth stimulated in a neighboring economy (low *total spatial linkage multiplier* values).

  The Morgantown-Fairmont case study on the other hand now can be further understood as each county (Monongalia and Marion) having strong internal economic linkages (high *spatial regional multipliers*), and room for their economies to become more reinforcing if mutually desired (low values for their *total spatial multiplier* as of 2002 and four of the top 5 employing sectors are in common). Monongalia County’s metro status explains in large part why this county has a *local spatial linkage* multiplier that is more than double that of Marion County.

  We can also understand that the Corridor K case study county of Cherokee, NC though transitional, exhibits as strong an internal employment multiplier and local spatial linkage multiplier as the corridor’s terminating metro counties which have competitive economic status. This result for Cherokee County can be attributed to the trade center role exerted by the City of Murphy on surrounding counties in NC, GA and TN.

- The second study focuses on enhancing our understanding of relationships between highways, ARC investments and subsequent economic growth over a long period of time. This work by Teresa Lynch of EDR Group utilizes time series regression techniques. It updates and extends a direction of research using "twin counties" that was initially developed by Andrew Isserman (see "The Economic Effects of the Appalachian Regional Commission", by Isserman and Rephann, 1995.) An improved specification for ADHS highway capacity and access was tested and found to significantly contribute to the differential income and earnings growth experienced from 1969 to 2000 for ARC counties relative to their twins' performance.

  The Scioto County case study in Volume 2 revealed that Scioto has been bypassed by recent highway investments while the ring of neighboring counties have benefited through improved highway access to the metro areas of Cincinnati, Columbus. These extra regional economies exert an adverse urban backwash effect on Scioto County that challenges any geographic predilection for it to serve as a thriving trade center.

  Likewise the partial explanation of positive differential growth outcomes for Appalachian counties from highway access improvements is a welcome expectation for the counties in SE Tennessee and SW North Carolina aligned along Corridor K. Whether improved economic outcomes result from better market reach of the region's eco-tourism and cultural heritage assets and/or eventual economic integration into the metro Appalachian counties that terminate the corridor (Hamilton Co., TN and Buncombe Co., NC) it will not occur without better access through the region.

- The third study focuses on enhancing our understanding of the relationship of business mix to (a) the size of the local population base and to (b) accessing quality air services. The analysis of market scale shows how trade centers differ in industry composition depending on market size. The analysis of airport access shows how highway drive times to airports also affect industry mix. This work by Teresa Lynch, Glen Weisbrod and Tyler Comings of EDR Group uses non-linear regression techniques and geographic information systems. It builds upon the prior ARC report, "Handbook for Assessing Economic Opportunities from Appalachian Development Highways" by Weisbrod et al., 2001.)

- The fourth study focuses on use of new advances in geographic and spatial analysis techniques to illustrate how proximity to mountains and roads affects economic development patterns and trends among counties. This work by Prof. Joseph Ferreira, Jr., Ayman Ismail, and Li Xin shows the use of GeoDa software for spatial analysis. It represents a pilot effort to demonstrate the value of spatial analysis to better understand factors affecting the economic development of Appalachian counties.

The case studies from Volume 2 that in part have some aspect of economic performance tied to physical terrain (as constraint or not) include Pike County KY and its neighbors in the Big Sandy Area, Scioto County OH embraced by two rivers, Corridor K's Cherokee County NC as trade center to a group of counties surrounded by a mountain ring, and for the case of Alabama an abundance of relatively flat land with broad highway coverage.

2 ECONOMIC BASE MODELING OF HUB AND SPOKE GROWTH PATTERNS

"Economic Base Modeling to Test Growth Patterns"
by
Ayman Ismail,
Massachusetts Institute of Technology

2.1 Introduction

This chapter presents an update of an economic base analysis of Appalachia's *distressed* and transitional (380 counties combined) counties using economic base theory which has been augmented to address possible spatial influences on a county's economic strength. This analysis was first conducted for the ARC (2000) by Smirnov-Smirnova to test whether distinct spatial growth patterns have a role to play in the performance of Appalachia's distressed, and near-distressed Transitional (153 counties at the time of the original analysis). The original study monitored employment growth performance (based on the strength of the regional employment multiplier) from 1992 through 1996. This update focuses on the period 1997 through 2002.

Summary of Original Research. In their "Assessment of the Economic-Bases of Distressed and Near-Distressed Counties in Appalachia," presented to the Appalachian Regional Commission (ARC) in 2000, Smirnov and Smirnova (hereafter referred to as S&S) use economic-base and location-quotient techniques to provide a detailed assessment and typology of 111 distressed and 42 near-distressed[1] counties in the Appalachian region in 1992 and 1996. The authors perform three key analyses to understand and assess the counties under study. First, they analyze the economic-base of distressed counties to identify their strengths and weaknesses and their potential for economic growth. The economic-base is defined as the collection of establishments in which the county specializes, where a county's employment in that industry is greater than the average for the rest of the country (i.e., it has an employment location-quotient greater than one).[2] Second, they identify the industrial-mix of economic-

[1] The ARC has since changed the terminology for the subset of transitional counties previously identified as *near-distressed* to *at-risk.*
[2] We will sometimes refer to the *economic-base* of a region as the *export-base*.

bases and regional spatial effects as important factors in shaping the regional economies of distressed and near-distressed counties. Third, they establish a typology for key parameters that characterize the economic potential of the economic-bases of distressed and near-distressed counties using regional employment multipliers and strength of spatial linkages; the latter measured by a spatial multiplier.

Based on their empirical analysis, S&S, identify several relationships and patterns that affect the economic development status in Appalachian counties:

- Within select types of economic-bases and specific classes of economic distress a strong relationship exists between the key parameters, such as population, employment, average wages, and per capita income of distressed and transitional counties. The S&S comparison of economic-bases between the distressed and near-distressed counties against the more prosperous economies in Appalachia reveals significant disparities in their key parameters.

- Regional employment multipliers show a direct (positive) relationship between the level of economic distress and the strength of the economic-base. In 1996, the average regional multiplier for distressed and near-distressed counties was 1.79, which is 11 percent lower than the average regional multiplier of 1.99 for all Appalachian counties. Distressed counties with higher values of regional multipliers tend to perform better and have higher economic growth potential than those with lower multiplier values.

- The industrial mix of the economic-bases of distressed and near-distressed counties is dominated by resource-oriented, technologically disadvantaged industries, many of which pay relatively low wages, have a low potential for growth of employment, and have little positive effect on local demand. The traditional components of Appalachia's industrial-mix are resource-oriented/extraction industries, such as coal-mining and agricultural production, where steady declines caused economic distress in affected counties. More dynamic and technologically advanced industries are virtually non-existent in the distressed areas of Appalachia.

- Spatial effects play an important role in shaping the economic-bases of all economies. The magnitude, direction, and scope of spatial effects for distressed and near-distressed counties differ from those of other counties in Appalachia. Distressed and near-distressed counties have very weak local and global economic linkages that lead to their limited economic opportunities and slow growth rates.

- The gap between distressed and prosperous counties in Appalachia is widening. On average, socio-economic parameters, such as population, employment, average wages, and per capita income of distressed and near-distressed counties, are growing at a substantially slower rate than they are in the rest of Appalachia. S&S identify four key characteristics as defining patterns of persistent self-reinforcing economic distress: *(1)* small size of rural economies, *(2)* non-diversified economic-bases, *(3)* stagnant industrial mixes, and *(4)* weak spatial linkages.

Based on these patterns, S&S find that the economic growth potential differs among distressed and near-distressed counties. There are a total of 13 distressed and near-distressed counties (termed Type I) that have well-diversified economic-bases, strong spatial linkages, and their economic-growth potential is as strong as that of prosperous counties in Appalachia. The majority of these counties are perceived as potential hubs—regions that are capable of propagating economic growth in the neighboring regions. Also, 21 counties (termed Type II) are approaching a similar level of potential for economic growth. An important distinction is that these counties form 'tight spatial clusters'. These counties are likely to overcome economic distress and achieve a pattern of self-sustainable economic growth, however, their economic development initiatives have to be coordinated at the multi-county level. In total these 34 counties, with somewhat diversified economic-bases and some economic-growth potential, form spatial clusters, which highlights the need for policies and initiatives that promote closer economic ties between neighboring counties. Exhibits 2-1 and 2-2 identify the counties whose economies have been portrayed as functioning as a regional hub or regional spokes.

Exhibit 2-1. Potential Regional "Hubs" from among Select Appalachian Counties, Smirnov (2000)

Distressed and Near-Distressed Counties with Growth Potential as Regional Hubs (13 counties) – Type I	
Spatial linkages are strong, economic base is strong and well-diversified, the type of economic base is either service-based or non-specialized	
Distressed Counties	**Near-Distressed**
Scioto, OH	*Talladega, AL
*Fayette, PA	*Allegany, MD
Raleigh, WV	*Belmont, OH
Randolph, WV	*Guernsey, OH
	*Jefferson, OH
	Cumberland, TN
	Tazwell, VA
	Greenbrier, WV
	Marion, WV
* Counties with both strong exports and local inter-county spatial links; other counties are those with only strong, local inter-county spatial link.	

Exhibit 2-2. Potential Regional "Spoke" Economies from among Select Appalachian Counties, Smirnov (2000)

Distressed and Near-Distressed Counties with Potential Influence on Neighboring Counties (21) – Type II	
Spatial linkages are relatively strong, economic base is relatively strong and relatively well-diversified	
Distressed Counties	**Near-Distressed**
Bell, KY Breathitt, KY Floyd, KY Harlan, KY Johnson, KY Knox, KY Perry, KY Pike, KY Rowan, KY *Whitely, KY Alcorn, MS Monroe, MS Oktibbeha, MS *Athens, OH *Gallia, OH Wise, VA *Logan, WV Upshur, WV	Jackson, KY Greene, TN McMinn, TN
* Counties with both strong exports and local inter-county spatial links; other counties are those with only strong, local inter-county spatial link.	

Complementary industrial and labor market linkages among closely located counties, or clusters of counties, have substantial beneficial effects for all counties involved, enhancing competitiveness of local products and services, and creating a base for successful multi-county industrial clusters. Poor choice of the industrial mix to be promoted in one county might undermine economic opportunities in the neighboring counties.

Update from the Spatially-augmented Export-base Analysis. The original analysis was updated for the Sources of Growth study using a more current set of data (years 1997, 2002) sourced from IMPLAN[3] and provided specifically for this task by the ARC. The analysis methodology is reviewed in the next section before presenting the findings for the 1997-2002 period. Additional information is provided in a separate Appendix document.

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[3] IMPLAN ® is an economic-impact modeling system provided by the Minnesota IMPLAN Group, Inc. Industry-level data are developed primarily from County Business Pattern data and select REIS data totals

2.2 Export-base Analysis Methodology

S&S derive a spatial export-base model by applying the principle of demand-driven modeling to the two-level hierarchy of regional economy emanating from the county level (the first being the county itself, and the second being the county and its neighbors). This results in a three-sector economy with one non-basic sector and two basic sectors (serving local and global exports). They use a county's employment in export-designated industries relative to the entire United States as an indicator of its economic-base; and location-quotients to identify a county's export employment in an industry against the rest of the United States. Based on this model, they perform four key analyses:

- Strength of economic-base using regional employment multipliers
- Strength of spatial linkages
- Degree of diversification in the economy
- Classification of counties by growth potential

Strength of the Economic-base. S&S use a concept of Regional Employment Multipliers (REM) to measure the strength of the economic-base. REM is defined as the number of new jobs generated in the county's economy as a result of an additional job in the export-base sector. Higher REM values correspond to a stronger economic-base.

The classical export-base model establishes that the total employment in the county (X) is the sum of export-base employment (E) and non-base employment (L):

$$X = L + E \qquad (1)$$

The critical assumption of the export-base model is that employment in the local sector is related only to the total employment in the county:

$$L = aX \qquad (2)$$

Where (a) is the requirement coefficient, which denotes the demand for local services by the regional economy, and $0 < a < 1$.

Combining (1) and (2), we obtain:

$$X = \frac{1}{1-a}E \qquad (3)$$

where the $\frac{1}{1-a}$ coefficient is the **Regional Employment Multiplier (REM)**, which indicates how change in the export-base employment affects the regional economy, i.e., every additional job in the export-base sector creates a total of X jobs in the regional economy.

The standard export-base model analysis approach does not include spatial elements in the parameters of the model, *e.g.*, county location or socioeconomic environment. These assumptions limit the application of the model to the analysis of large geographical areas, such as states.

Strength of Spatial Linkages. S&S modified the export-base model to include spatial linkages to the neighboring counties and the rest of the world, based on a two-region model (Exhibit 2-3). The first region is represented by a county (County A). The second region is represented by the *expanded region of neighboring counties*, which comprises the county and its direct neighborhood of adjacent counties. The export base model for that region is similar to the single county case:

$$X^R = L^R + E^R \tag{4}$$

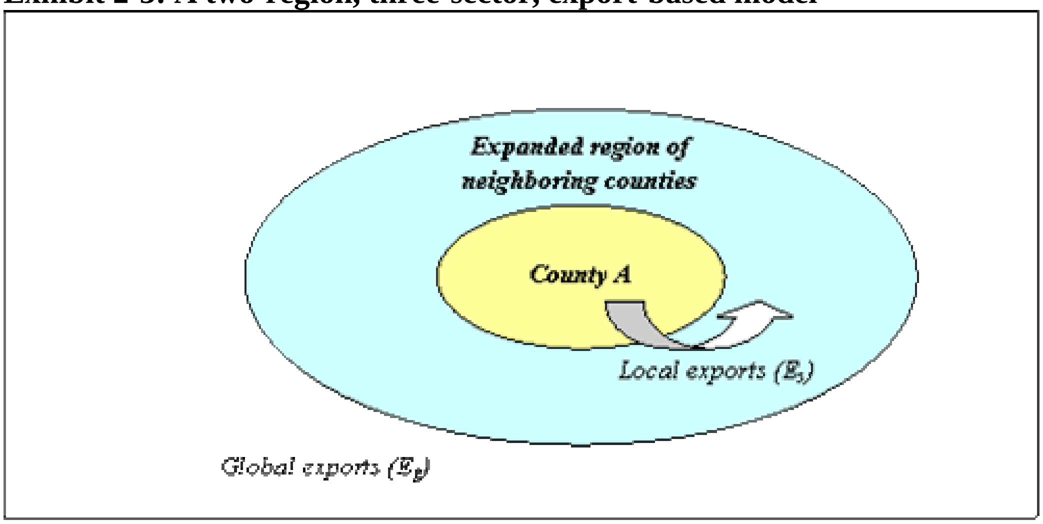
$$L^R = cX^R \tag{5}$$

Total employment in the context of this expanded region is related to the employment in the basic sector via the multiplier effect:

$$X^R = \frac{1}{1-c} E^R \tag{6}$$

The spatial export-base model implies no cross hauling within the aggregate multi-county region; i.e. a sector's product exported to the neighboring counties is not subsequently exported.

Exhibit 2-3: A two-region, three-sector, export-based model



Source: MIT Multiregional Planning Research Group.

This spatial export-base model links two levels of the regional hierarchy: (1) the county model, and (2) the expanded region of neighboring counties model. Exports from a county comprise two components: local exports E_s (exports to the expanded region of neighboring counties) and global exports E_g (exports beyond the county and its neighborhood).

$$X = L + E_s + E_g \tag{7}$$

where (X) is the sum of the export-base employment ($E = E_s + E_g$) and non-base employment (L); (E_s) is the portion of the export-base employment attributed to exports to the neighboring counties, and (E_g) is the portion of the export-base attributed to global exports (exports beyond neighboring counties).

This spatial export-based model leads to a three-sector economy, with a county's economy consisting of three sectors, one local non-basic sector and two basic sectors. We maintain the assumption of the classical export-based model that the employment in the local sector is related only to the total employment in the county:

$$L = aX \tag{8}$$

County A's first basic sector is the sector that provides goods and services to the second basic sector in the expanded region. Assuming a linear relationship, we determine employment in this basic sector by:

$$E_s = bE^R = b(E_g + E_g^l)\,. \tag{9}$$

where (E_g^l) is the size of the global export-base in the neighboring regions (counties), coefficient b (where $0 < b < 1$)[4] is a coefficient that indicates the requirement for employment tied to local export activities in the county and its spatial neighborhood.

The second basic sector is associated with goods and services supplied outside the expanded region. This assumption is a logical extension of the classical export-base model, which aims to explain employment in all sectors of the regional economy via

[4] The technical and economic bounds on the values of the coefficients: The bounds on the value of coefficient b are determined from practical considerations of model use. The lower bound b = 0 implies that all county exports are global, i.e. industrial mix of the county is identical to the industrial mix of the aggregated region. The upper bound, b = 1, still does not imply that all exports are local. However, high values of the coefficient b >=1 would have implied a "super-efficient" job-creation by global exports: one job created in the global export would have made a direct impact of equal or larger magnitude on the local exports. While technically this situation is possible, it simply suggests that the global export industry is a pass-through industry, which is instrumental, but not the reason, for the global exports. For example, if local export is generated by manufacturing in county A, and global exports is a shipping company in the neighborhood of county A, then the co-location of the two industries is driven by the demand on the manufacturing goods. High values of the coefficient b contradict the major economic assumption of the export-base model, which postulates the demand-driven economy. For this reason, any value of b close to 1, such as 0.8 or 0.9 should be taken as an indication of potential violation of model assumptions. (Communication from Smirnov, 1/30/2006)

the employment in the basic sector. In the case of the spatial export base model, it is a three-sector model: global export (basic-2) – local export (basic-1) – non-basic employment. Eventually, the employment in the second basic sector determines the employment in all other sectors.

The addition of spatial interactions to regional export-base model introduces the concept of *regional neighborhood*. Regional neighborhood can be understood as the sphere of immediate economic influence of a county's economy. That influence is exerted via common infrastructure, economic linkages, shared labor pools, etc. Because most of these effects quickly decay with geographical distance, it is reasonable to assume initially that only cross-county border interactions affect neighboring counties. In this study, we use the physical contiguity criterion to define regional neighborhood.

This regional neighborhood is represented by the contiguity matrix. This is a matrix of zeros and ones, with an element S_{ij} equal to one if counties *i* and *j* are geographic neighbors. This denotes that these two counties may have close economic ties with each other and that their economic-bases are interdependent. In contrast, the element S_{ij} is equal to zero if two counties are not contiguous. The diagonal elements in the matrix are set to zero because our definition of global export excludes the county's output[5].

It should be noted that other neighborhood "constructs" could be used in this type of spatial modeling exercise. For example, a test of the hypothesis that the relationships among the different counties are a function of the cross-county trade flows rather than geographic adjacency would require generating a similar *spatial weights* matrix with elements S_{ij} equal to one if counties *i* and *j* pass a certain threshold of cross-county trade flows activity. Comparing the effect of the spatial linkages based on these two different notions of adjacency, would illustrate the relative strength of geographic neighborhood vs. trade flows on the economic influence exerted among these counties.

The principal distinction between the classical export-base model explained in Equations (1) and (2) and the modified spatial model explained in Equations (7), (8), and (9) is that for the latter, the export-base is segmented into two components and the "local" oriented export-base is linked directly to global export activities in the neighboring counties.

By combining Equations (7), (8), and (9), we obtain Equation (10):

$$X = \frac{1}{1-a}[b(E_g + E_g^l) + E_g] \qquad (10)$$

[5] For this updated analysis, the contiguity matrix was assembled using GeoDa[5]. The "Queen" concept from chess was chosen for calculating contiguity, which includes all the neighboring counties whether they are adjacent at a single point or have a common border with the county. This is in contrast to the "Rook" concept, which includes contiguous neighbors only if they share a border with the respective county.

which can be rearranged into Equation (11):

$$X = \frac{1+b}{1-a}E_g + \frac{b}{1-a}E_g^l \tag{11}$$

Equation (11) is the reduced form of the spatial version of the export-base model. Both coefficients (*a*) and (*b*) are county-specific; however, in the case of the non-spatial version of the model, (a) alone would be the only parameter. Values of these parameters characterize the industrial mix of the regional economy at the aggregate level, based on the aggregation of NAICS-level estimates.

Two multipliers are important in this model. First, $\frac{1+b}{1-a}$ is the **Spatial version of the Regional Employment Multipliers (SREM)**, which denotes how much increase in employment in the county will occur from a unit increase in its global exports. The introduction of the spatial effects increases its value slightly from the value in the non-spatial version. The second multiplier $\frac{b}{1-a}$ measures the **Local Spatial Linkage (LSL)**, which indicates how much the employment in the county will increase as a result of a unit increase in the export-base employment in the neighboring counties.

Guided by this model, the Location Quotient (LQ) method[6] was used to calculate these multipliers. For each industry in a county, the LQ indicates the following: if the industry employs more (less) than the average in the reference area, which is the United States, we denote it as an export (local) industry. The LQ was also used to apportion the employment dedicated to export activities in an industry.

LQ values were computed for each of 85 industries in each of the 410 Appalachian counties and the U.S. (as the reference region) for 1997 and 2002.

In the spatial version of the export-base model, two regions are involved: one explicitly (the county in question) and one implicitly (the county's spatial neighbor(s) which includes itself). Building on this, we compute the local and global exports using the following process:

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[6] The LQ was calculated as follows:

$$LQ = \left(\frac{E_{ij}}{E_{in}}\right) \Big/ \left(\frac{E_j}{E_n}\right) \tag{12}$$

where, E_{ij} is employment of industry j in county i ; E_{in} is total employment in county i; E_j is employment of industry j in the whole United States; E_n is total employment in the whole United States. If employment data are unavailable, an analyst can use output, value added, or some other data that is available for each county.

First, we compute export-base employment of the county in question (county A) using the location-quotient method, and export-bases of all its individual neighboring counties. Summing these numbers, we obtain an estimate of neighborhood's aggregate exports, E_T. This value represents the sum of all local and global exports from the county and its spatial neighbor(s).

Second, we compute the export-base of an aggregated region, i.e., the region composed of the county and its spatial neighbor(s) including any contiguous non-Appalachian counties, denoting the result as E_G. This number represents the export-base of the aggregated region, or from the perspective of county A, total global exports.

Third, we compute the ratio $(1-\frac{E_G}{E_T})$, which represents the **Total Spatial Linkages (TSL)**. This ratio is always a positive number between zero and one. Its value depends on the industrial mix of the economy of county A and that of its spatial neighbor(s). A small value for the TSL ratio indicates that the economy of a county and its spatial neighbors have similar economic-bases (*competing* substitutes) and have limited interactions with each other. At the limit, if these economies have an identical industrial mix, the TSL ratio will be equal to zero. The value of the TSL ratio is higher when the economy of the spatial neighbor(s) complements that of county A. At the limit, when these economies are perfect complements and the industrial mix of the aggregated economy is identical to the reference area, the TSL ratio will be exactly one.

Using the TSL ratio $(1-\frac{E_G}{E_T})$, we compute E_g and E_s for county A:

$$E_s = (1-\frac{E_G}{E_T})E \quad (13)$$

$$E_g = \frac{E_G}{E_T}E \quad (14)$$

where E is the export-based employment and is equal to the sum of E_g and E_s.

Degree of Diversification in the Economy. S&S measured the degree of diversification (or concentration) of employment in a county by the percent of total employment accounted for by the top five industries[7]. For example, in Bibb County, Alabama, the top five industries listed in Exhibit 2-4 employ 55% of the total labor force, indicating a 55% degree of diversification. A large number indicates a high

[7] Other measures of industrial diversification may be used to give a different picture, for example, comparing the concentration by sector to the concentration in the region as a whole or to a larger reference region like the United States. This measure is often used in many 'diversity indices' used in the analysis of ethnic and racial diversity in urban areas. For the purpose of this paper, we followed the same diversification index used in the S&S (2000) paper to enable cross-comparison of the results.

concentration of a few industries in the county, and a low number indicates a more diversified economy.

Exhibit 2-4: Example of Degree of industry diversification

County FIPS, Name		Industry	Rank	Employment
01007	Bibb County, Alabama			
		92 Government & non NAICs	1	1,216
		230 Construction	2	621
		113 Forestry & Logging	3	324
		321 Wood Products	4	312
		814 Private households	5	307
		Industry Diversification (Percent of employment in top five industries):		55%

Source: MIT Multiregional Planning Research Group.

Classification of Counties by Growth Potential. S&S divided the counties into four groups based on the values of spatial regional employment multipliers (SREM) and local spatial linkages (LSL). In Exhibit 2-5, we define the criteria for the county typology, and in Exhibit 2-6, we illustrate this classification system. In the Appendix, we include the numerical thresholds used for the classification for 1997 and 2002 evaluation.

Exhibit 2-5: County Typologies

Type	Definition	Criteria
Type I	Counties with a strong economic-base, i.e., spatial regional employment multipliers (SREM) in top quartile, AND strong local spatial linkages (LSL).	SREM in top quartile **and** LSL in top half
Type II	Counties with strong local spatial linkages and a relatively strong economic-base relative to Appalachian counties, i.e., spatial regional employment multiplier in second quartile.	SREM in second quartile **and** LSL in top half
Type III	Counties with either a weak economic-base, i.e., spatial regional employment multipliers being less than the median, OR weak local spatial linkages	SREM in bottom half **or** LSL in bottom half (excluding Type IV)
Type IV	Counties with a weak economic-base, i.e., spatial regional employment multiplier in bottom quartile, AND weak local spatial linkages.	SREM in bottom quartile **and** LSL in bottom half

Source: Smirnov and Smirnova (2000).
SREM = Spatial Regional Employment Multipliers; LSL = Local Spatial Linkages

Exhibit 2-6: Calculations of County Typology

SREM / **LSL**	**Top quartile** *75%*	**Second quartile** *median*	**Third quartile** *50%*	**Bottom quartile** *25%*
Top half *Median*	**Type I**	**Type II**	**Type III**	**Type III**
50% **Bottom half**	**Type III**	**Type III**	**Type III**	**Type IV**

Source: MIT Multiregional Planning Research Group; based on Smirnov and Smirnova (2000).
SREM = Spatial Regional Employment Multipliers; LSL = Local Spatial Linkages

Data Methodology. While there are several sources of public and private employment data for the county-level economies, this updated analysis relies upon a current IMPLAN data set provided specifically for this analysis through the ARC. The data set covers all the 410 Appalachian counties as well as 137 contiguous non-Appalachian countries for 1997 and 2002. It covers 85 industries in each county, using the three-digit North American Industrial Classification System (NAICS) classification[8].

There are substantial methodological differences in the nature of data sets used in this report and the 2000 S&S study, which relied upon *Clean* CBP & REIS data sets:

- The IMPLAN data set is based on industry-level data with an algorithm to estimate suppressed data points, while the CBP data is the aggregate of establishment-level data (with data suppression issues). The result is slightly different notion of an 'industry' in both data sets.
- Each data set uses a different level of industry aggregation.
- IMPLAN uses NAICS codes, while CBP data used for the initial study was in terms of SIC codes.

Additional data issues are presented after the current analysis' results are compared to the original findings by Smirnov.

[8] This data set does not include the inter-industry trade relationship or the county-to-county trade flows. These data would be useful in getting a deeper and more detailed understanding of the cross-county and inter-industry dynamics using techniques like input-output analysis. Some of these additional data sets may be available commercially, but were not available for this study.

2.3 Overview of the Results

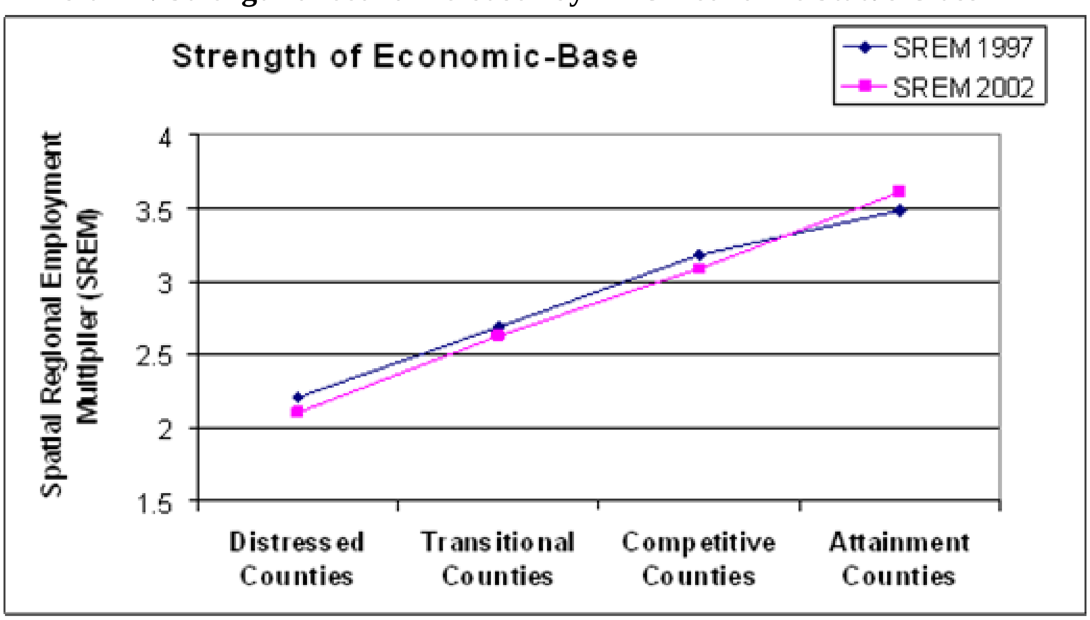
Using Structured Query Language (SQL), the following four indices from the Smirnov analysis were recomputed for each Appalachian county for 1997 -2002:

- Strength of economic-base using regional employment multipliers
- Strength of spatial linkages
- Degree of diversification in the economy
- Classification of counties by growth potential

Strength of the Economic-Base. The Spatial Regional Employment Multiplier (SREM) indicates the strength of the economic-base by measuring the number of new jobs generated in the county's economy as a result of an additional job in the export-base sector. To compare the SREM across the different types of economic-attainment counties, we calculate the average SREM for groups of counties based on their ARC designated economic status.

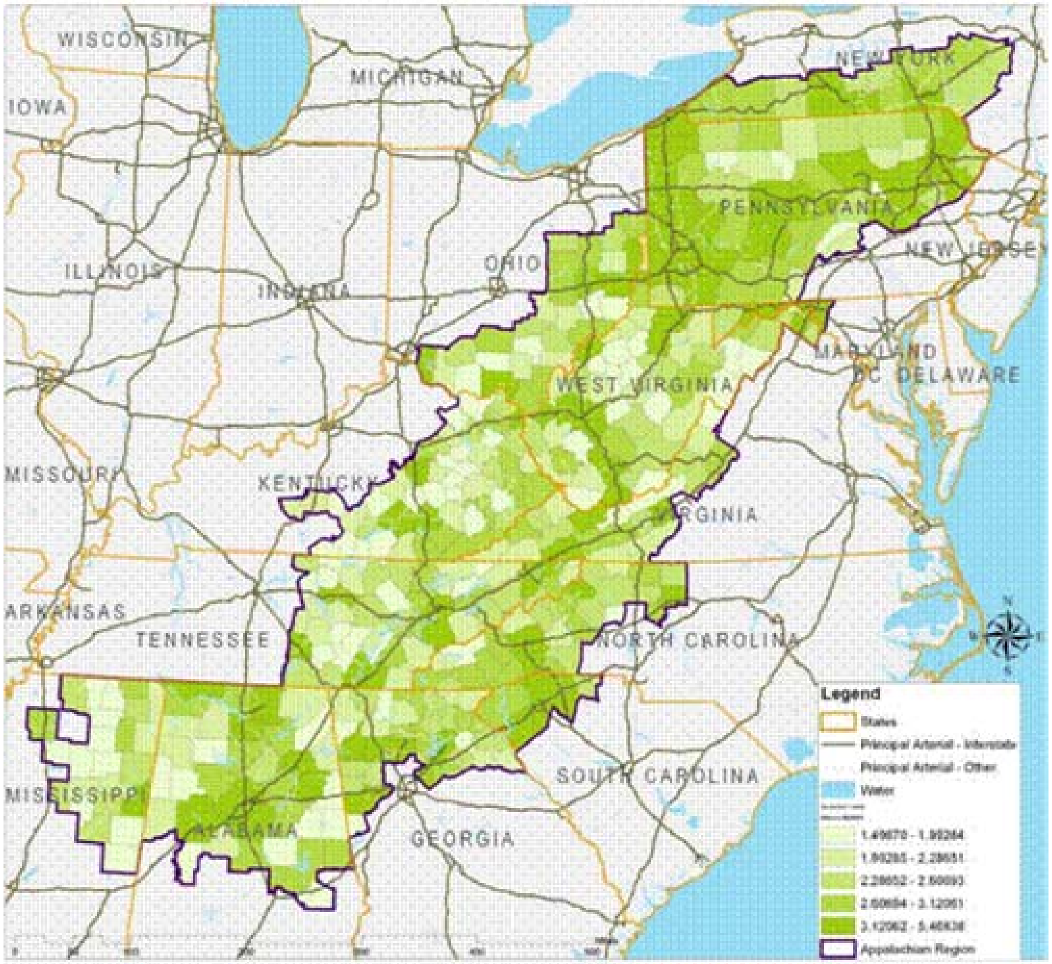
By examining these aggregate results for the Appalachian region (Exhibits 2-7 and 2-8), we identify two clear trends. First, there is a very limited (3%) difference between the SREM values across all counties between 1997 and 2002. Second, the SREM values increase linearly from the distressed counties to the attainment counties, indicating an increasing effect of the economic-base industries in the higher attainment counties. For example, in 2002, a new job in an export-based industry produced, on average, 2.1 jobs in a distressed county, compared to 3.6 jobs in an attainment county – a 58% difference.

Exhibit 2-7: Strength of economic-base* by ARC Economic Status Class



SREM = spatial regional employment multiplier; Source: MIT Multiregional Planning Research Group

Exhibit 2-8: **Mapped Distribution of the 2002 spatial regional employment multipliers (SREM)**

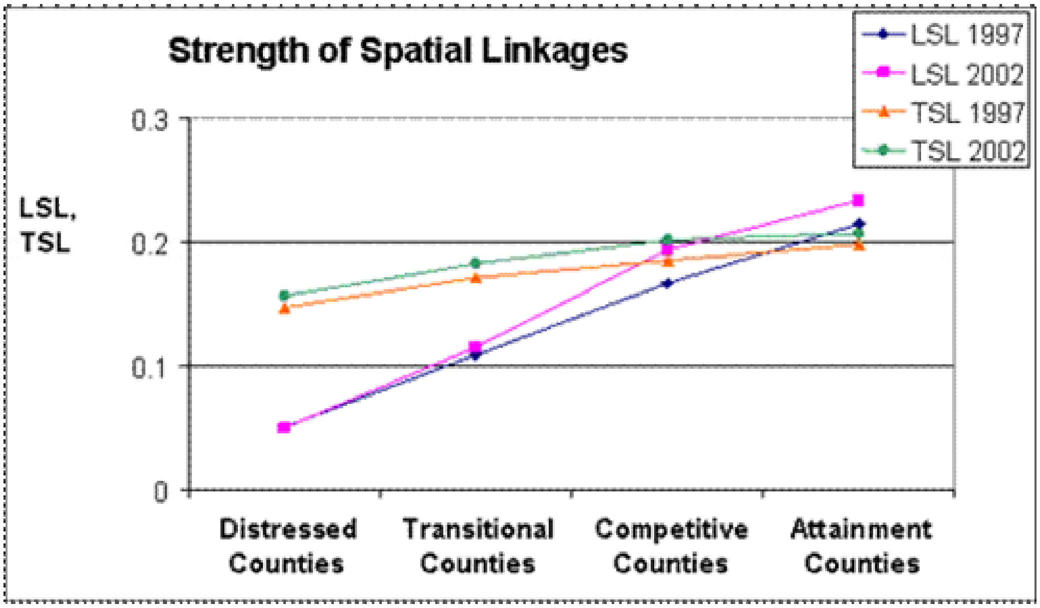


Source: MIT Multiregional Planning Research Group.

However, it is hard to specify the direction of the causality in this relationship. It could be that counties with industries that have higher SREM values have better opportunities for additional growth, as the export activity spurs forward and backward linkages. It could also be that counties that are economically developed have a more advanced and diversified economy such that the exporting firms can maximize local sourcing, rather than importing them from other counties. (The Appendix contains the complete SREM values for each of the 410 Appalachian counties for 1997 and 2002.)

Strength of Spatial Linkages. **"Local Spatial Linkage (LSL)"** is a measure of how much employment in a county will increase as a result of a unit increase in the export-base employment in the neighboring counties (Equation 11). LSL values (Exhibit 2-9 and 2-10) are significantly higher in competitive and attainment counties, compared to the distressed and transitional counties. This indicates that a county has higher economic linkages with neighboring counties. For example, in 2002, LSL = 0.05 in distressed counties, compared to LSL = 0.23 in attainment counties. Higher LSL values suggest that neighboring economies are more integrated and, therefore, more responsive to economic policies. This may be a result of the local geography, where attainment counties may contain residential neighborhoods next to an industrial county, where the impact of jobs in the industrial county trickles down to the neighboring suburban residential county.

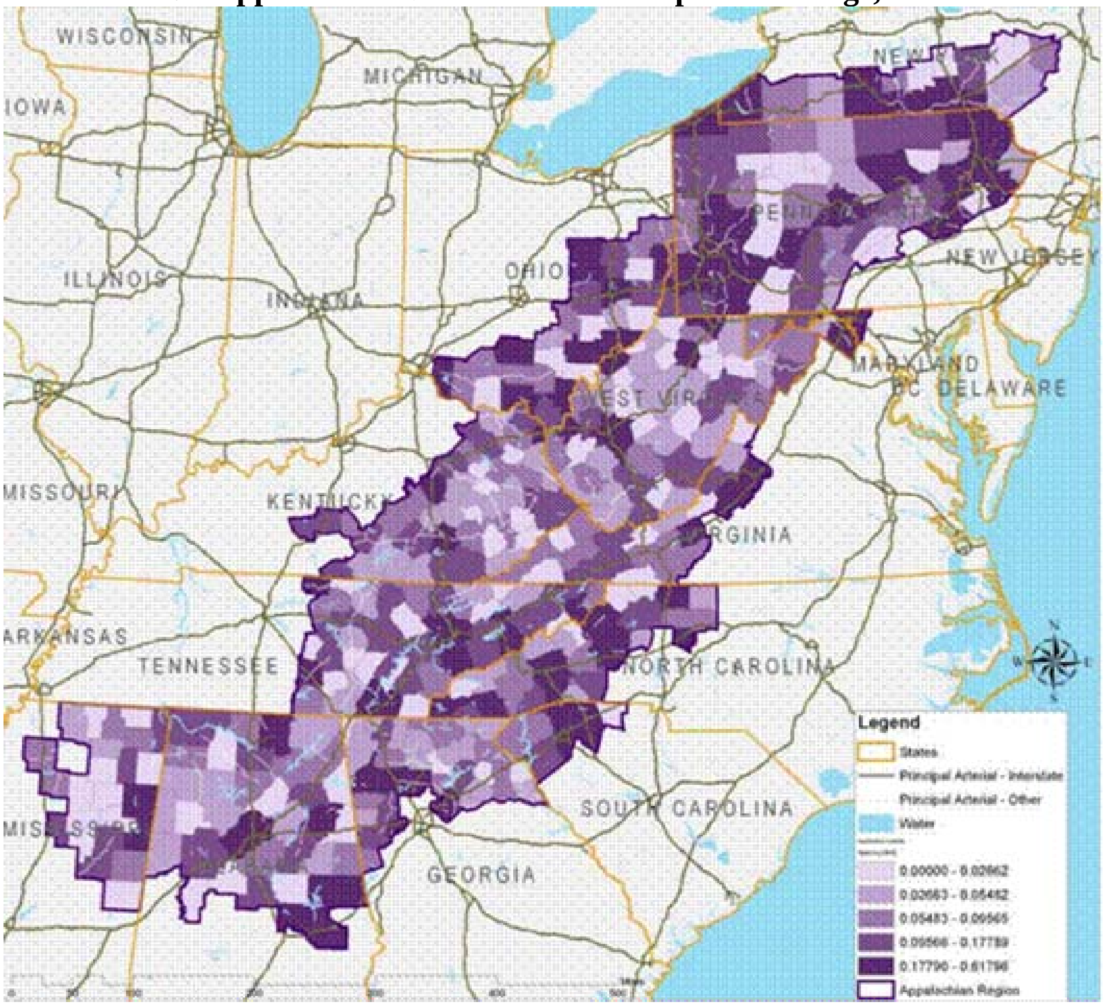
Exhibit 52-9: Strength of local spatial linkages (LSL) and total spatial linkages (TSL), 1997 and 2002



Source: MIT Multiregional Planning Research Group.

Total Spatial Linkage (TSL) is a measure of the similarities/differences in the industrial mix between a county and its spatial neighbor(s). TSL is a positive number between zero and one. A high TSL value indicates that the economy of the county is different and complements that of its spatial neighbor(s). A small value for TSL indicates similar economic-bases between the county and its spatial neighbors where they have limited interactions among each other (substitutes). TSL values (Figures 5.5) are higher for attainment counties indicating more complementarities with their spatial neighbors, compared to distressed counties that have more similarities with their spatial neighbors, indicating less potential for economic integration. For example, in 2002, TSL = 0.21 for attainment counties, compared to 0.16 for distressed counties.

Exhibit 2-10: Mapped Distribution of the Local Spatial Linkage, 2002



Source: MIT Multiregional Planning Research Group.

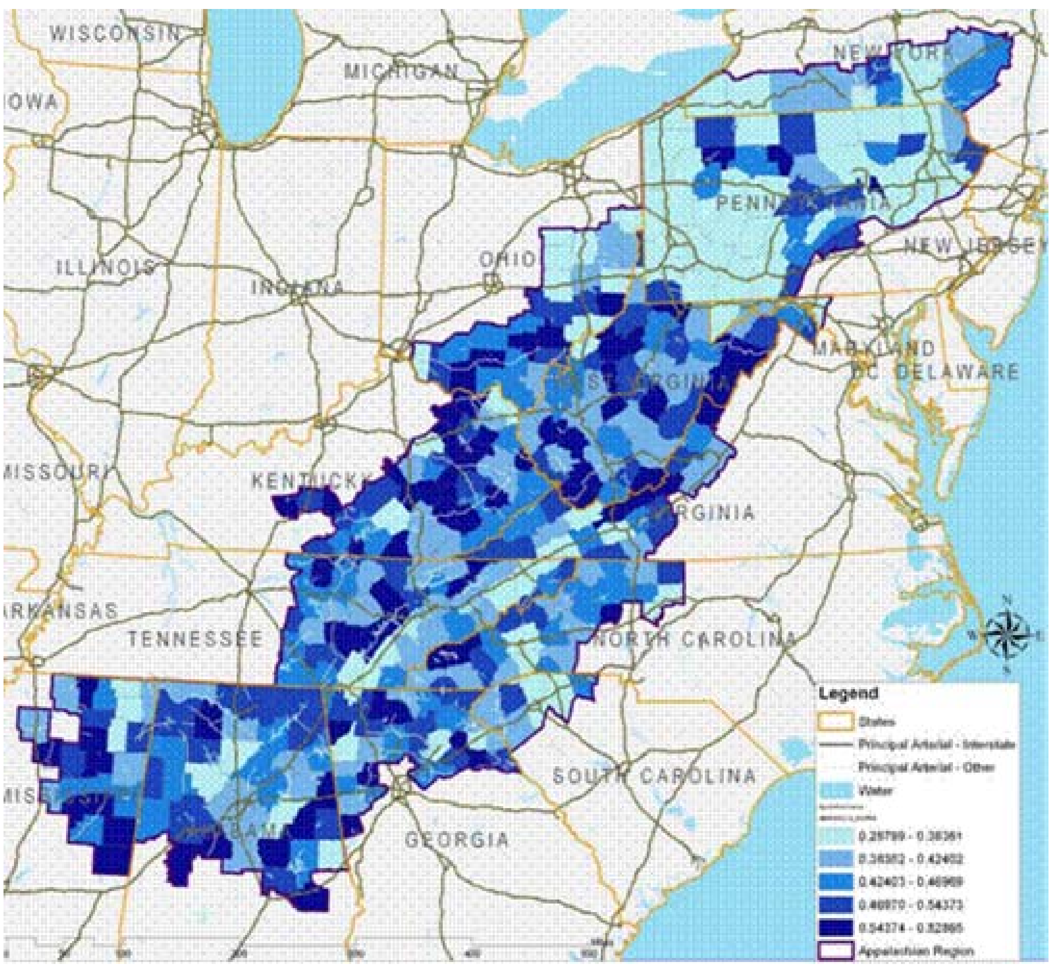
Degree of Diversification in the Economy. The degree of diversification or concentration of employment in a county is measured by the percent of total employment in the county tied to the top five industries. For 2002, 42% of the employment in the competitive and attainment counties was concentrated in the top five industries (Exhibits 2-11 and 2-12). However, the transitional and distressed counties had more concentration, with 45% and 53%, respectively. These values have changed little between 1997 and 2002, except for distressed counties, in which the concentration in the top five industries increased by 6.9% from 0.494 to 0.528. The industrial concentration in distressed and transitional counties indicates more vulnerability to cyclical recessions in these individual industries. Most of the distressed and transitional counties have small economies, where these top industries often represent a small number of establishments with large employment (Smirnov and Smirnova 2000), thus the impact of factory closures or relocation can significantly affect employment in the county economy.

Exhibit 2-11: Average values for Industry Diversification, by County economic-status

Economic-Status	1997	2002	Percentage Change (1997-2002)
Distressed	0.494	0.528	6.9%
Transitional	0.437	0.451	3.2%
Competitive	0.431	0.424	-1.5%
Attainment	0.422	0.425	0.6%

Source: MIT Multiregional Planning Research Group

Exhibit 2-12: Mapped Distribution of County-level Industry diversification in Appalachia, 2002



Source: MIT Multiregional Planning Research Group.

Classification of Counties by Growth Potential. Based on the results for 2002, the ARC county distribution among the S&S typology (Exhibit 2-13 and 2-14) is overall consistent with the economic development status of the counties, e.g., a large number of the distressed and transitional counties are classified as Type III and Type IV, while most of the competitive and attainment counties are classified as Type I and Type II. We can use this classification to help identify counties that could serve as "anchors" or "hubs" for a regional economic development strategy, e.g., Type I counties that are distressed (1) and transitional (81) have strong employment multipliers and local spatial linkages.

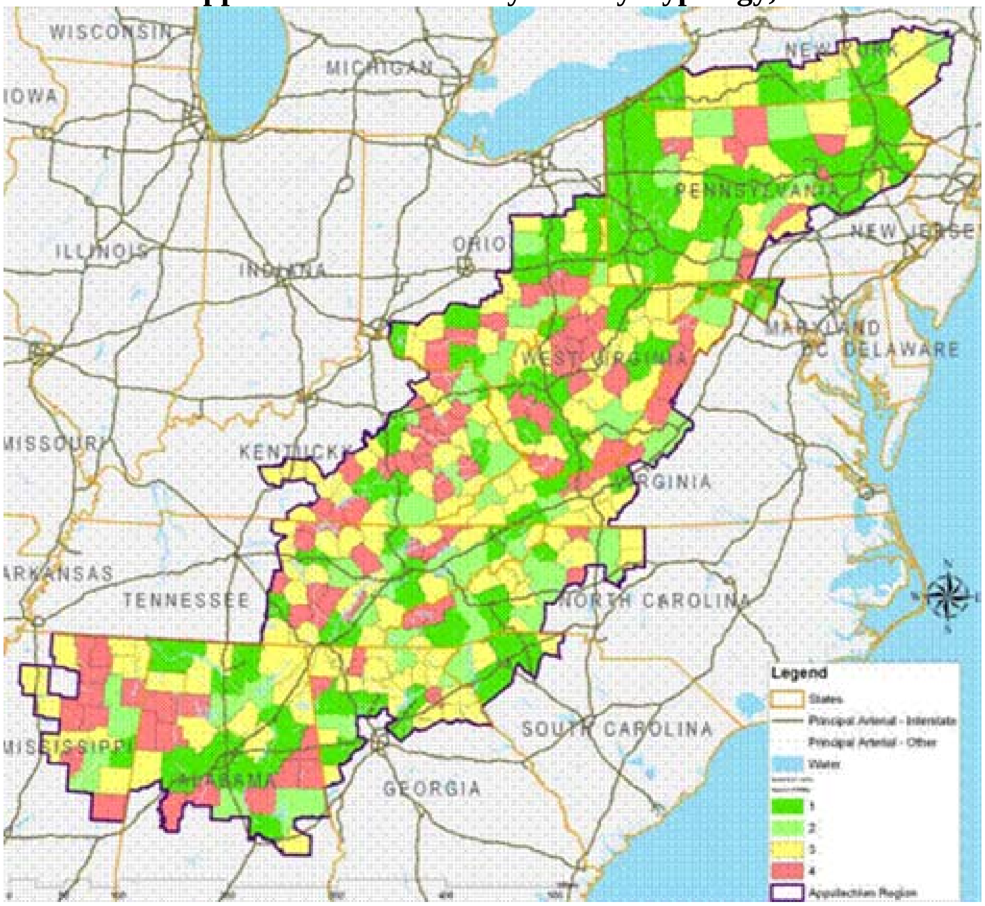
The transitional counties are more numerous than the set of distressed Appalachian counties and exhibit more heterogeneity (i.e., spread across the different types) in the composition of economic-base and therefore display a broader reaction to economic stimuli. Type I and II transitional economies are more likely to respond favorably to economic growth in the neighboring counties. In contrast, Type III and IV transitional and distressed counties will have less benefit. This suggests two policy implications. First, if officials target Type I and II counties for investments, they are likely to obtain a favorable growth response. Second, the overall effect in Appalachia of local initiatives will be higher for counties that are surrounded by Type I or II counties; and limited in the case of counties surrounded by Type III and IV counties, because all the linkages lead to outside-of-the-region interactions.

Exhibit 2-13: Appalachian Counties by S&S Typology and Economic Status

Economic Status	Type I	Type II	Type III	Type IV
Distressed	1	9	32	35
Transitional	81	52	118	52
Competitive	12	2	6	2
Attainment	5	1	2	0

Source: MIT Multiregional Planning Research Group.

Exhibit 2-14 Appalachian Counties by County Typology, 2002



Source: MIT Multiregional Planning Research Group.

2.4 Uses and Limitations of the Findings

This analysis provides some useful insights into the development potentials of the distressed and transitional counties based on their export-base. However these indices should not be used in a vacuum when making county-level policy decisions or investment allocations. This section points to some of the strengths and limitations of the methods and data under-pinning this analysis which can serve to both (a) assist users of this report in interpreting the spatial economic-base implications for their county(ies) of interest, and (b) guide future follow-up work that may utilize a similar methodology.[9]

Strengths of the Economic-Base Model. The computed indices may be useful at the aggregate level to provide a picture of the economic capabilities in the Appalachian

[9] This section benefited significantly from comments from Luc Anselin, Lisa Petraglia, Karen Polenske, Oleg Smirnov, and Glen Weisbrod.

region. By examining the results of this analysis in comparison with the results of the original S&S analysis, we can highlight three key points that illustrate the strength of this approach. First, the quantitative characteristics of the counties did not change significantly from 1997 to 2002. Second, when we do a back-of-the-envelope comparison of the county typology for some counties between the original S&S computations for 1996 and the 2002 computations done for the present study, we find limited change in how a county is rated Type I through IV. This is an indication of both the consistency of the methodology despite the change in data sources and aggregation, and it also shows that there was little change in the Appalachian counties during that period. However, we would need to conduct a systematic comparison between the results of the two analyses to confirm this point. Third, the current results when applying the S&S typology may explain some of the differences between attainment and distressed counties vis-à-vis their economic-bases and spatial linkages.

Limitations of this Analysis. The use of this analysis should be guided by the limitations of the theory, methodology, and data.

- **Economic-Base Model** - In general, the key limitation of the economic-base model is its sensitivity to definitional issues in the computation. Analysts using the economic-base model must make two theoretical assumptions: (1) the reference region is a closed-economy, i.e., all economic activities happen within the region, and there is no trade activity between the reference region and outside the region; (2) all counties throughout the region have identical productivity and consumption levels (Kim 1995).

  For the first assumption, we use the United States as our reference region, assuming that all U.S. export/import activities happen within the country, and no one county exchanges goods with areas outside of the United States. The United States was chosen as the reference area in this study in order to compare Appalachian counties with other U.S. counties in terms of their economic-base performance. However, this may have limitations in counties (Appalachian or not) that have significant exports to areas outside of the United States.

  For the second assumption, we assume that, throughout the United States, labor productivity as well as consumers' tastes and expenditure patterns, and households' income levels are identical. This assumption implies evenly distributed demand and supply of each product in proportion to the population within the reference area.

- **Location-Quotient (LQ) Method** - LQ is a useful technique to identify export-based industries in a region; however, its accuracy depends on many factors including the reference area and level of data aggregation.

  First, for the **reference area**: we performed the same analysis twice using *all of Appalachia* and then the United States as the reference areas, and noticed a significant difference in the LQ values. This difference would trickle down through the computations, and would produce a different picture for the export-based industries. Although the results may remain similar across different time periods if the same computation method is used, analysts need to be careful in the interpretation of the results in either case.

Second, for the **level of data aggregation**: we use three-digit NAICS codes (85 industries) to calculate the LQs and identify export sectors. In theory, the results may vary depending on what data level of industrial classification an analyst uses to calculate the LQs. Using data at a more disaggregated level (larger number of industrial sectors), tends to produce more 'accurate' results.[10] For example, with an analysis at the three-digit NAICS code level, a researcher will not detect some detailed export-based industries due to aggregation bias; but, at a four-digit level of analysis, one or two sub-sectors may appear as export sectors. However, when we compare the county-level aggregate outcomes and the resulting county typology from the S&S paper with the current results, there are no significant *ordinal* changes in the relationships among the counties (the ranking and typology), yet *cardinal* differences do exist, i.e., differences in the values of the LQs and multipliers.

- **Spatial Linkages Concept.** Spatial linkages, as computed in this analysis, provides limited resolution as to the role of cross-sector linkages (input-output accounts would illuminate key inter-industry relationships capitalized upon in a county). Nor can one explicitly identify the role that a county's personal income (predominantly made up of wage earnings) plays in the strength of the spatial linkages when household fulfill their demands for goods and services. It is also important to keep in mind that the terms *multiplier* and *linkage* represent different concepts than those terms connote in traditional input-output analysis.

- **County Classification.** While the S&S county classification (Type I through IV) is a useful tool to avoid the variations in multiplier values due to the use of different data sets, two issues limit the usefulness of this classification. First, the two dimensions used in the county classification (SREM and LSL) are not orthogonal, i.e., they are correlated (SREM = (1/1-a) + LSL). The use of orthogonal dimensions is required for effective classification. Second, the classification does not take into account the standard error of the multiplier values. This would affect counties on the borderline between different types.

- **Data Issues and Comparability of Results.** Since the current analysis used a different source of data than the one used in the 2000 S&S report (IMPLAN vs. *Clean* CBP/REIS data), there are issues with the comparability of the results. These issues stem from the different levels of aggregation in the establishment/industry data sets. Specifically one is limited in making a direct comparison of individual values for multipliers for county-industry pairings. To reliably overcome this and be able to make comparisons of the results between the

[10] Consequently, using more aggregated data tends to produce higher values for the regional multipliers.

two analyses comparative ranking among the different counties/industries can be used. In doing so there is a strong correlation of the county classification results between the two reports, indicating a robustness of the results of the analysis at the aggregate level, despite the difference in the level of data aggregation, time period, industrial classification (SIC vs NAICs), and data source. This comparison also highlights the limited change in the (relative) economic structure in the Appalachian counties over the past decade.

Applying the Results of this Analysis. Given the strengths and limitations of this analysis, we describe different approaches to make use of this analysis in the field and the potential for future research studies that would build on this analysis.

First, using this analysis, we can create profiles for each county, highlighting the multipliers, the top industries, and the typology. However, the local county community cannot take solitary action based on these profiles since by definition they reflect the influences of neighboring counties. A second approach would be to use this analysis for a cross-county comparison to understand the relative characteristics of these counties. This may be useful to understand the relationships between economic attainment and the parameters computed in this analysis, e.g., the industry diversification or concentration, or the regional linkages. A third approach is to use the county typology to identify potential "growth hubs" at the regional level. This is similar to what S&S use in their paper (see Exhibit 5.1 above), where they identify counties with strong spatial linkages and economic-base as potential agents for triggering regional growth in their neighborhood. A fourth approach in using this analysis is to identify possible counties or groups of counties for future case studies to examine the spatial forces at work on each county in a neighborhood.

The most important point to emphasize in using such an analysis at the individual county level is that it is not unusual that the computed figures would vary from the reality in the individual counties. This is due to several factors in the data collection, measurement errors, aggregation effects, and assumptions embedded in the computation process. When using these results in individual counties, an analyst needs to do a "reality check" to ensure that the results are not anomalies. A reality check should turn up consistency with existing economic changes/transactions. This becomes crucial when communicating these results to local communities, or when using them for county-level decisions.

2.5 References

Fingleton, Bernard, Danilo C. Igliori, and Barry Moore. 2003. "Cluster Dynamics: New Evidence and Projections for Computing Services in Great Britain, Regional Economics," Paper presented at conference *Economic Geography and Clusters* (January). Cambridge, UK.

Kim, Hong-Bae. 1995. *Urban and Regional Economics: Analysis and Estimation.* Seoul: Kimundang.

Smirnov, Oleg, and Alena Smirnova. 2000. "An Assessment of the Economic-bases of Distressed and Near-Distressed Counties in Appalachia: A Report to the Appalachian Regional Commission." Washington, DC: ARC

Smirnov, Oleg. 2002. "Measuring Self-Sustainability of Economic Development at the County Level," The Annals of Regional Science. 36(4): 683-696.

3 Twin Counties Study Update

“The Impact of Highway Investments on Economic Growth in the Appalachian Region, 1969-2000: An Update and Extension of the Twin County Study”

By Teresa Lynch, Economic Development Research Group

3.1 Introduction

This chapter estimates the impacts of highway investments on economic growth in Appalachian counties between 1969 and 2000. The chapter has two objectives. The first objective is to update the 1995 study by Isserman and Rephann (I&R), which found statistically significant differences in economic growth rates of ARC counties when compared to their non-ARC counterparts in the 1965-1991 period, and that counties served by the Appalachian Development Highway System (ADHS) had even higher rates of income, population, and per capita income growth than otherwise similar (non-ARC) counties (1995; p.359). We extend this analysis to year 2000.

The second objective is to determine whether the amount, characteristics, and timing of ADHS investments can explain some of the differences in economic outcomes. In the Isserman and Rephann study, “ARC program variables are almost never statistically significant” (p.362), a finding we hypothesized might be due to the blunt measures of ARC program variables used in that study. To improve the quality of the highway investment variable, we surveyed state DOTs on the timing and characteristics of ADHS segments in their states, including construction start and end dates, section length, number of lanes, access type, number of signalized intersections, and number of interchanges. All thirteen ARC states participated fully in the survey process.

The critical empirical finding of this research is that (on average) the gap between ARC counties and their twins grew significantly in the 1990s. Relative to their non-ARC county twins, income in ARC counties had grown 131% more over the 1969 to 2000 interval; earnings growth was 96% higher; population growth was 9% higher; and per capita income was 36% higher. The performance of ARC counties with ADHS segments relative to their twins was even more impressive: income growth alone was over 200% higher for the 1969 to 2000 interval. The overall performance on the ARC region during this period, though, should not mask the struggles that pockets within ARC have experienced: performance in the northern part of the ARC regions lagged its non-ARC twins and across the region, smaller metropolitan areas fell far behind their non-ARC counterparts.

The critical methodological finding from this chapter is that one reason top-down methodologies approaches have often failed to establish a link between highway investments and Appalachian development is poor measurement of highway investments. Using the improved highway measures afforded by our survey, we were able to establish a statistical link between ADHS investments and differential income and earnings growth between ARC counties and their twins.

We found that better measures of highway investment characteristics (e.g., new versus replacement investment; length of segment relative to county size) generated explanatory relationships that were statistically significant and robust, whereas poor measures of investment did not. This suggests that when characteristics of the proposed highway investments are properly measured, there is empirical support for claims that highway investments--here in the form of the ADHS investments--contribute to economic growth.

3.2 Appalachian Growth, 1969-2000

A key question for national policy makers and ARC members, partners, and staff concerns the effectiveness of different ARC programs on improving economic outcomes in Appalachia. Isserman and Rephann’s 1995 study--which was subtitled “An Empirical Assessment of 26 Years of Regional Development Planning”--compared economic growth in Appalachian counties to growth in a control group of non-Appalachian counties (“twins”). The purpose of the control group is to proxy what would have otherwise occurred (in terms of growth) without ARC funding. The authors posit that once identified, the difference in the mean cumulative growth rates informs us whether there are real growth gains for the Appalachian county. To complete the study’s objective, the authors attempted to identify the causal factors (through regression analysis) behind *significant* real growth differentials in favor of Appalachian counties.

Clearly then, much rests upon (a) the methods to select a non-Appalachian county twin, and (b) assessing how suitable each “match” is before advancing the growth analysis. The set of 391 non-Appalachian twin counties identified by Isserman and Rephann are used in our current update of their analysis which follows.

Eligible non-Appalachian counties for selection as a possible match were predicated on the following:

- The county’s population centroid had to be at least 60 miles away from the Appalachian border
- Comparable growth in personal income, earning by sector over the period 1950-1959

- Comparable economic structure (earnings by sector) and population in 1959

Since a qualifying non-Appalachian county might provide a match to more than one Appalachian county, the final matching was guaranteed to reflect the optimal set by applying a distance weighting on the proposed pairs in the set of 391 Appalachian counties. The solution that had the minimum Mahalanobian distance[11] defined the optimal pair matches. The validity of the 391 match counties to serve ultimately as the "counter-factual" for Appalachian growth over the 1969-1991 period in the absence of ARC investments was confirmed statistically by the authors albeit with a slight bias.[12]

Isserman and Rephann (referred to here as "I &R") found that on average, ARC counties outperformed their twins by significant margins over the 1969-1991 period: income and earnings growth in ARC counties was 48% higher (cumulatively) while per capita income growth was 17% higher. These differences were statistically significant (at the 10% level). The results were more ambiguous when county type was taken into account: large metropolitan (statistically insignificant however) and non-metropolitan counties (particularly those in the *Central* Appalachian subregion) fared much better than their twins, but smaller metropolitan areas (those with populations under 250,000) demonstrated a statistically significant finding of lower income, earnings, and per capita income growth than their twins. For non-metro areas, income, earnings, and per capita income differences were statistically significant.

These findings only reflect performance through 1991, neglecting the question of how ARC counties fared during the 1990s. To answer this question, we use the same data and the same control group as Isserman and Rephann (I&R). The data are from the U.S. Bureau of Economic Analysis and provide information on population, personal income by source, and earnings by industry by county for 1969-2000. These data, termed the "REIS" data,[13] provide a long time series and do not suffer from the data suppression issues that other potential data sources (e.g., County Business Patterns) do. We also use the same control group, namely the "twin county" matches developed by I&R and used in different studies of the Appalachian region.[14]

Exhibits 3-1, 3-2 and 3-3 provide the relevant data on ARC growth since 1969. Exhibit 3-1 reproduces the mean growth rate differences between Appalachian counties and their twins for the period 1969-1991 reported by I&R. Exhibit 3-2 presents updated estimates of the 1969-1991 mean growth rate differences using the most recent REIS data.[15] (The latter estimates are expected to differ from those of

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[11] Mahalanobian distance accounts for correlations between variables, as discussed in Isserman & Rephann (1995)

[12] Over the 1950-1959 period the Appalchian counties exhibitied a slightly more moderate rate of growth than the 391 non-Appalachian match counties – a manifestation that Appalachian counties pre-ARC investments (1965 inception) were uniquely disadvantaged locations. This bias would only serve to understate the role of ARC investments over 1969-1991 should significant, positive growth differentials be observed.

[13] "REIS" is the acronym for "Regional Economic Information System."

[14] We thank Andrew Isserman for providing a list of the county matches used in Isserman and Rephann, 1995.

[15] REIS data used in this report were downloaded in late 2005.

I&R in Exhibit 3-1 because of changes in methods used in REIS, as well as the periodic updating of data sets by BEA.) Exhibit 3-3 presents mean growth rate differences between Appalachian counties and their twins for the 1969-2000 period.

Two matters stand out about the data. The first is that the more recent REIS data (shown in Exhibit 3-2) show a somewhat different picture of ARC performance for 1969-1991 than presented by I&R (shown in Exhibit 3-1). Both data sets show that ARC counties outperformed their twins across all measures in the 1969-1991 period; that certain characteristics (e.g., presence of ADHS segment) are associated with strong economic performance and others (e.g., metropolitan status with less than 250,000 in population) with weak performance; and great variability in performance of ARC counties by region and state. The more recent data, though, suggest that income growth was significantly higher in ARC counties than previously thought (68% higher than their twins between 1969 and 1991 compared to 48% in I&R); that the northern region of ARC outperformed its twins between 1969 and 1991; and the southern ARC region had more noticeably outperformed their twin counties with respect to income growth (aggregate and per capita) and earnings growth than originally measured.

Exhibit 3-1. Isserman & Rephann's Reported Mean Growth Rate Differences, 1969-1991

	Income	**Earnings**	**Population**	**Per Capita Income**	**Manufacturing**	**Retail Trade**	**Services**	**No. of Counties**
Appalachia	48%	48%	5%	17%	87%	67%	138%	**391**
Northern	-6%	-11%	-3%	7%	-76%	13%	46%	**143**
Central	101%	92%	7%	51%	427%	99%	131%	**86**
Southern	68%	78%	10%	8%	63%	99%	222%	**162**
Alabama	8%	33%	1%	-4%	94%	33%	127%	**35**
Georgia	199%	262%	35%	7%	101%	247%	689%	**35**
Kentucky	118%	105%	7%	68%	530%	112%	147%	**49**
Maryland	112%	95%	5%	72%	77%	173%	167%	**3**
Mississippi	27%	7%	7%	-17%	55%	60%	95%	**18**
New York	-2%	-3%	-2%	5%	1%	-4%	0%	**14**
North Carolina	53%	21%	0%	40%	-49%	101%	139%	**29**
Ohio	-11%	-2%	3%	-23%	-20%	-29%	36%	**28**
Pennsylvania	6%	-2%	-2%	16%	-70%	39%	58%	**52**
South Carolina	151%	130%	24%	12%	98%	191%	87%	**6**
Tennessee	68%	72%	10%	8%	277%	90%	119%	**50**
Virginia	36%	-18%	-3%	46%	191%	-38%	79%	**17**
West Virginia	-26%	-26%	-8%	15%	-179%	9%	22%	**55**
Metropolitan	50%	64%	8%	4%	110%	70%	205%	**95**
<250,000	-65%	-86%	-11%	-8%	-160%	-42%	-11%	**27**
Non-metro	48%	43%	4%	22%	80%	66%	115%	**296**
Appalachian HWY	69%	49%	6%	32%	61%	78%	92%	**110**
Interstate HWY	41%	48%	4%	15%	125%	70%	148%	**152**
Growth Center	37%	40%	4%	14%	101%	62%	85%	**90**
Coal Producing	51%	41%	1%	38%	77%	47%	73%	**148**
Distressed County	48%	31%	2%	28%	168%	55%	92%	**113**

Note: **Boldface** indicates significance at the 10 percent level.

Exhibit 3-2. Recent REIS Data Calculated Mean Growth Rate Differences, 1969-1991

	Income	Earnings	Population	Per Capita Income	MFG	Retail Trade	Services	No. of Counties
Appalachia	**68%**	**59%**	**6%**	**27%**	79%	**66%**	**170%**	**391**
Northern	**8%**	**3%**	-2%	**16%**	-85%	29%	**69%**	**143**
Central	**119%**	**89%**	**7%**	**57%**	**346%**	**69%**	**195%**	**84**
Southern	**94%**	**92%**	**11%**	**21%**	93%	**98%**	**248%**	**164**
Alabama	51%	56%	2%	22%	105%	44%	**179%**	**35**
Georgia	**221%**	**278%**	**38%**	9%	64%	**224%**	**741%**	**35**
Kentucky	**134%**	**96%**	**7%**	**61%**	517%	69%	**235%**	**49**
Maryland	110%	107%	5%	67%	129%	158%	248%	**3**
Mississippi	0%	-39%	5%	-26%	-1%	**55%**	9%	**18**
New York	6%	10%	-25%	-3%	-6%	14%	23%	**14**
North Carolina	**87%**	40%	-1%	**60%**	-32%	78%	126%	**29**
Ohio	8%	12%	2%	-3%	25%	2%	-36%	**28**
Pennsylvania	14%	6%	-1%	**20%**	**-65%**	**46%**	**78%**	**52**
South Carolina	**158%**	**148%**	**24%**	17%	**129%**	**196%**	12%	**6**
Tennessee	**113%**	**98%**	**11%**	**36%**	**257%**	**102%**	**167%**	**50**
Virginia	7%	-30%	-3%	25%	212%	-28%	110%	**17**
West Virginia	-2%	-3%	-6%	**26%**	**-225%**	23%	107%	**55**
Metropolitan	**84%**	**80%**	9%	**21%**	147%	71%	**198%**	**76**
<250,000	**-53%**	-57%	**-10%**	0%	-90%	-26%	63%	**31**
Non-metro	**62%**	**51%**	**4%**	**29%**	52%	**65%**	**160%**	**284**
Appalachian HWY	**92%**	**69%**	**7%**	**42%**	147%	**81%**	**194%**	**139**
Interstate HWY	**63%**	**60%**	5%	**27%**	125%	**69%**	**153%**	**162**
Growth Center	**79%**	**87%**	**8%**	**28%**	42%	**121%**	**175%**	**124**
Coal Producing	**74%**	**67%**	3%	**40%**	93%	**53%**	**142%**	**134**
Distressed County	**69%**	33%	3%	**40%**	139%	**48%**	**169%**	**115**

Note: **Boldface** indicates significance at the 10 percent level.

Exhibit 3-3. Recent REIS Data Calculated Mean Growth Rate Differences, 1969-2000

	Income	Earnings	Population	Per Capita Income	MFG	Retail Trade	Services	No. of Counties
Appalachia	**131%**	**96%**	**9%**	**36%**	132%	**127%**	**424%**	391
Northern	**-34%**	-48%	-5%	8%	-151%	0%	**77%**	143
Central	**191%**	**84%**	5%	**93%**	625%	**131%**	**387%**	84
Southern	**245%**	**228%**	**22%**	**31%**	146%	**236%**	**757%**	164
Alabama	4%	-33%	-1%	-5%	-35%	-31%	183%	35
Georgia	**780%**	**933%**	**79%**	**32%**	**583%**	670%	**2940%**	35
Kentucky	**205%**	79%	6%	**94%**	**1181%**	**128%**	**437%**	49
Maryland	160%	101%	4%	88%	-46%	123%	521%	3
Mississippi	34%	-12%	6%	-15%	-26%	**138%**	67%	18
New York	-54%	-47%	-8%	7%	-75%	-69%	19%	14
North Carolina	**194%**	70%	4%	**116%**	-166%	177%	356%	29
Ohio	-20%	-8%	-1%	-15%	-63%	-14%	-97%	28
Pennsylvania	-7%	-12%	-1%	15%	-130%	24%	46%	52
South Carolina	**308%**	**236%**	**34%**	15%	**149%**	**465%**	117%	6
Tennessee	**239%**	**134%**	**19%**	**54%**	203%	**249%**	**319%**	50
Virginia	-35%	-73%	-9%	44%	15%	-79%	205%	17
West Virginia	-80%	-98%	**-13%**	18%	**-265%**	-3%	174%	55
Metropolitan	**201%**	186%	17%	15%	146%	157%	**770%**	76
<250,000	**183%**	**-200%**	**-17%**	**-40%**	**-436%**	**-164%**	13%	31
Non-metro	**105%**	**62%**	**5%**	**44%**	127%	**116%**	**292%**	284
Appalachian HWY	**202%**	**117%**	**12%**	**63%**	96%	**163%**	**516%**	139
Interstate HWY	93%	117%	6%	**23%**	333%	108%	**426%**	162
Growth Center	**133%**	182%	9%	**40%**	102%	**229%**	**510%**	124
Coal Producing	**96%**	50%	1%	**54%**	92%	**70%**	**284%**	134
Distressed County	**96%**	3%	0%	**72%**	456%	**76%**	**250%**	115

Note: **Boldface** indicates significance at the 10 percent level.

The second noteworthy finding concerns the performance of ARC counties in the 1990s. As the data in Exhibit 3-3 show, by 2000, income in ARC counties had grown 131% more since 1969 than in the non-ARC counties; earnings growth was 96% higher; population growth was 9% higher; and per capita income was 36% higher. Mean growth rate differences (relative to twins) in counties with ADHS segments grew from 92% for the 1969-1991 period to 202% for the 1969-2000 period. At the same time, the 1990s saw the northern region of ARC fall behind its non-ARC counterparts; and income and earnings growth in the 31 smaller metropolitan counties (populations less than 250,000) dropped from about 50% less than their twins through 1991 to about *200*% less than their twins by 2000.

The performances of individual states also varied widely, ranging from 80% less than the twins to 780% more. Interestingly, the states that performed best (and significantly so) relative to their twins (Georgia, Kentucky, and South Carolina) seemed to do so in part on the strength of their performances in manufacturing.

3.3 The Role of Highway Investments

By adopting the "twin county" approach, itself a version of the comparison group methodology, we share an important assumption with I&R: that differences in growth rates between ARC counties and their twins represent "what would have happened in Appalachia without the ARC," i.e., without ARC programs. Although I&R were unable econometrically to establish a robust relationship between ARC programs (growth centers, distressed counties, and highway investments) and economic outcomes in Appalachian counties, it is possible that their results reflect poor measurement of program variables rather than weak program effectiveness. The poor quality of program measures is evident in the treatment of highways in their regression model: I&R roll ADHS and interstate highway investments into one binary variable ("Highway in County"), which takes a value of "1" if the county is home to at least 3 miles of ADHS or interstate and a "0" otherwise. The crudeness of this measure, we believed, might be the reason it was not possible to establish a statistical relationship between highway investments and economic growth.

To improve the quality of the highway investment variable, we surveyed state DOTs regarding the timing and characteristics of ADHS segments in their states, including construction start and end dates, section length, number of lanes, access type, number of signalized intersections, and number of interchanges. (A sample survey is presented at the end of this chapter.) Each of the 13 ARC states participated fully in the survey. Survey data were added to the REIS data on economic performance to create a dataset of highway investments and economic outcomes.

Before testing the new dataset for causal determinants of growth differentials between Appalachian counties and their twins, we attempt first to reproduce I&R's findings for the 1969-1991 period, then extend their analysis to year 2000. The results are presented in Exhibit 3-4, which show reasonable consistency with I&R's results. Specifically, for the analysis of income growth in ARC counties and their twins in the 1969-1991 period ("INC 91"), the two sets of findings are in accordance on the sign and significance of 14 of 18 of the variables used in the original I&R model specification. For the analysis of earnings growth ("EARN 91"), the analyses are also in accordance on 14 of the 18 variables. Some of the differences that do exist can likely be attributed to how the variables were constructed. (For example, the economic structure variables used in I&R are defined as the contribution of farm, manufacturing, retail, and government sectors to county total income in 1959, while this analysis used 1969 data because of issues of timing and data availability.) Others are likely due to differences in old and new REIS estimates of earnings and income for this period.

Despite these differences, the current analysis reproduces the key finding of the original I&R analysis: that the presence of an interstate and/or ADHS highway segment cannot explain earnings or income growth patterns in ARC counties in the 1969-1991 period. (However, unlike the findings of I&R, the “highway” variable is positively and significantly correlated with per capita income, a finding that should be further explored in a later study.) These results also hold when the analysis is extended to examine the difference in income or earnings growth between 1969 and 2000 (“INC 00” and “EARN 00”).

Exhibit 3-4. Regression Results Using Isserman and Rephann Specification
(dependent variable is differential Income or Earnings growth by 1991 or 2000)

Explanatory Variable	INC 91	INC 00	EARN 91	EARN 00
(Constant)	1.273	4.243	.645	1.269
South Region	**1.010**	**3.071**	**1.059**	**2.692**
Central Region	**1.154**	**2.308**	**1.019**	**1.630**
Distance to City of 25,000	**.014**	**.049**	**.015**	**.056**
Distance to City of 100,000	-.006	**-.023**	***-.008***	***-.023***
Distance to City of 250,000	-.003	***-.015***	**-.003**	**-.012**
Distressed Counties 1990	-.159	-.660	***-.663***	-1.187
Growth Center	-.108	-.596	-.059	-.217
Coal Producing	*.313*	*.278*	.443	.359
Mahalanobis Distance	***-.039***	-.078	-.004	-.011
Population Density, 1960	-.001	-.003	-.001	-.002
% Farm in Earnings, 1969	-.018	-.016	**-.038**	*-.052*
% Manu in Earnings, 1969	**-.026**	**-.080**	**-.026**	**-.062**
% Ret Trade in Earnings, 1969	-.001	.024	.025	.092
% FedGovCiv in Earnings, 1969	.025	-.041	.043	-.055
% FedMil in Earnings, 1969	-.090	-.282	-.079	-.199
% St/Local in Earnings, 1969	.014	.001	***.039***	.068
Population Growth Rate, 1950-60	**.022**	**.060**	**.021**	**.059**
ADHS or Interstate	.204	.641	-.079	.359

Bold indicates the regression coefficient is significant at the 10 percent level in both analyses;
Bold italics indicates variable is significant in current analysis but not in I&R analysis;
Italics indicates variable is significant in I&R but not in current analysis

For the second part of the analysis, we refined I&R’s single “highway” variable by decomposing it into its component parts, ADHS and interstate investments. Using a model specification that mimics the I&R model in all ways except that the “highway” variable is now disaggregated into separate “Interstate” and “ADHS” components, we find that the presence of an ADHS segment in a county can in fact explain a portion of differential income growth for 1969-1991 ("INC 91") and 1969-2000 ("INC 00"), as well as differential earnings growth in the 1969-2000 period ("EARN 00"). These results are presented in Exhibit 3-5.

Exhibit 3-5. Regression Results Delineating Interstate and ADHS Investments
(dependent variable is differential Income or Earnings growth by 1991 or 2000)

Explanatory Variable	INC 91	INC 00	EARN 91	EARN 00
(Constant)	1.355	4.669	.600	1.365
South Region	**1.000**	**3.033**	**1.054**	**2.667**
Central Region	**1.129**	**2.210**	**1.009**	1.575
Distance to City of 25,000	**.013**	**.045**	**.015**	**.054**
Distance to City of 100,000	**-.008**	**-.028**	**-.009**	**-.027**
Distance to City of 250,000	-.003	**-.013**	-.002	**-.012**
Distressed County	-.149	-.627	-.654	-1.161
Growth Center	-.113	-.603	-.076	-.243
Coal Producing	.289	.209	.424	.294
Mahalanobis Distance	**-.040**	-.086	-.005	-.013
Population Density, 1960	-.001	-.003	-.001	-.002
% Farm in Earnings, 1969	-.017	-.015	**-.037**	-.051
% Manu in Earnings, 1969	-.025	**-.076**	**-.025**	**-.059**
% Ret Trade in Earnings, 1969	-.003	.017	.024	.087
% FedGovCiv in Earnings, 1969	.025	-.039	.044	-.055
% FedMil in Earnings, 1969	-.080	-.245	-.068	-.170
% St/Local in Earnings, 1969	.015	.005	**.041**	.072
Pop. ulation Growth Rate, 1950-60	**.022**	**.062**	.021	**.059**
Interstate	-.059	-.569	-.181	-.194
ADHS	**.421**	**1.552**	.207	**1.003**

***Bold** indicates the regression coefficient is significant at the 10 percent level*

To get yet a better measure of highway investments, in the third part of the analysis we use survey results to refine the "ADHS" variable to reflect the size (in lane-miles) of the segment relative to the size of the county; and the type of investment (new, widen, or replace) represented by each segment. These data were combined to produce estimates of lane-miles per county for 1991 and 2000, which were then refined by dividing by the land area in each county. This calculation yielded an estimate of the size of each type of ADHS segment relative to county size for 1991 and 2000.

Using these measures of highway investments confirms a relationship between ADHS investments and county-level income and earnings growth differentials relative to the non-ARC twin outcomes. However, as shown in Exhibit 3-6, the effect on earnings growth does not appear in the 1969-1991 growth rates but emerges for the 1969-2000 growth rates, supporting the hypothesis that business sector response to highway improvements is slower than the residential sector. (Note: income measures are by place of residence, earnings are by place of work.) This interpretation gets further support from the results in Exhibit 3-7, which show that when the highway investment variable refers to investments in place by 2000 (rather than those in place by 1991, as in Exhibit 3-6), the impact on income and earnings growth is smaller.

Exhibit 3-6. Results Using 1991 ADHS Segment Length Relative to County Size ***(dependent variable is differential Income or Earnings growth by 1991 or 2000)***

	INC 91	INC 00	EARN 91	EARN 00
(Constant)	1.397	4.631	.537	1.154
South Region	**1.019**	**3.123**	**1.033**	**2.664**
Central Region	**1.227**	**2.663**	**.978**	**1.703**
Distance to City of 25,000	**.013**	**.042**	**.015**	**.053**
Distance to City of 100,000	-.006	**-.022**	**-.008**	**-.023**
Distance to City of 250,000	-.003	**-.014**	-.002	**-.012**
Distressed Counties 1990	-.138	-.529	**-.642**	-1.075
Growth Center	-.094	-.520	-.083	-.213
Coal Producing	.407	.651	**.479**	.553
Mahalanobis Distance	**-.042**	-.092	-.006	-.015
Population Density, 1960	-.001	-.003	-.001	-.002
% Farm in Earnings, 1969	-.020	-.024	**-.037**	-.053
% Manu in Earnings, 1969	**-.026**	**-.078**	**-.024**	**-.058**
% Ret Trade in Earnings, 1969	-.004	.010	.026	.087
% FedGovCiv in Earnings, 1969	.026	-.035	.046	-.048
% FedMil in Earnings, 1969	-.085	-.240	-.066	-.157
% St/Local in Earnings, 1969	.011	-.006	**.039**	.067
Population Growth Rate, 1950-1960	**.023**	**.060**	**.021**	**.058**
Interstate	-.104	-.702	-.190	-.239
NewPerMileLandArea91	**4.550**	**22.146**	2.063	**14.249**
ReplacePerMileLandArea91	-2.125	-4.234	-2.204	-3.092
WidenPerMileLandArea91	-1.270	-5.317	2.334	2.987

The findings in Exhibit 3-6 also suggest that only some types of investments are likely to influence local economic activity. As the results in Table 6 show, the variable that measures lane miles of new highway construction (“NewPerMileLandArea91”) is positive and significant in the income and earnings growth equations for the 1969-2000 period. The variables for “replaced” and “widened” lane-miles per land area, however, are not significant for income or earnings in either period. The “NewPerMileLandArea91” variable is also significant in the 1969-1991 period for the income variable, although the effect is larger for the 1969-2000 period. Because the vast majority (80+ %) of lane-mile investments in place in 2000 were actually made pre-1991, these findings also suggest that there is a considerable lag between highway investments and their full effect on economic growth.

Exhibit 3-7. Results Using 2000 ADHS Segment Length Relative to County Size
(dependent variable is differential Income or Earnings growth by 2000)

Explanatory Variable	INC 00	EARN 00
(Constant)	4.727	1.147
South Region	**3.037**	**2.588**
Central Region	**2.438**	1.532
Distance to City of 25,000	**.045**	**.055**
Distance to City of 100,000	**-.023**	**-.025**
Distance to City of 250,000	**-.014**	**-.012**
Distressed Counties 1990	-.509	-1.077
Growth Center	-.527	-.256
Coal Producing	.552	.422
Mahalanobis Distance	-.092	-.017
Population Density, 1960	-.003	-.002
% Farm in Earnings, 1969	-.022	-.049
% Manu in Earnings, 1969	**-.080**	**-.057**
% Ret Trade in Earnings, 1969	.024	.098
% FedGovCiv in Earnings, 1969	-.032	-.042
% FedMil in Earnings, 1969	-.260	-.164
% St/Local in Earnings, 1969	-.009	.071
Population Growth Rate, 1950-1960	**.068**	**.062**
Interstate	-.740	-.220
NewPerMileLandArea00	**14.783**	**9.148**
ReplacePerMileLandArea00	-5.474	-1.394
WidenPerMileLandArea00	-.832	8.422

3.4 Uses and Limitations of the Findings

Whereas the prior study examined Appalachian economic growth over the 1965-1991 period, this new study updates it to the year 2000. It confirms the general findings of the prior study that ARC is making a difference. The ARC counties are now outperforming comparable non-Appalachian counties in terms of income and earnings growth. It also confirms a general finding that economic performance is weaker and more problematic in the rural and micropolitan counties than in the larger metro counties.

However, this new expanded analysis adds information not previously available. This research effort included development of a large base of data on Appalachian Development Highway system mileage, lanes, and construction years, by county. Using this more detailed dataset, the new study found statistically significant evidence that the completion and presence of an ADHS segment in a county does lead to greater economic growth. It found that "lane miles of new highway construction" (mostly built prior to 1990) is a significant predictor of income and earnings growth occurring later during the 1990s but not in earlier years. This indicates that the economic development impact of new highways can take many years to unfold. It also supports the finding that business sector response to highway improvements can be slower than the residential sector response. The study also found that "new construction," but not "replacement" or "widening," led to a notable impact on economic growth.

Beyond the highway impact, the study of long-term trends also showed that the states performing best relative to their non-Appalachian "twins" (i.e., Georgia, Kentucky, South Carolina, and Tennessee) appeared to do so in part on the strength of their performances in manufacturing. This reinforces the finding that manufacturing clusters are still an important source of economic growth.

This research effort shows the importance of continual updating and analysis of economic trends in Appalachian counties, as economic growth patterns continue to evolve in new ways. It also shows the need for further study to better untangle: (a) interactions of ADHS and interstate highway system improvements, (b) differential impacts of highway expansion and new construction, and (c) impacts on per capita income vs. growth of aggregate income and earning power (which also reflects population changes).

3.5 Survey Instrument

The following three pages contain the survey letter and form. The survey was filled out by each of the thirteen state transportation departments, and provided information on Appalachian Development Highway sections in each state, including dates of construction of various highway sections, information on mileage, lanes, intersections, interchanges and traffic counts.

APPALACHIAN REGIONAL COMMISSION

A Proud Past, A New Vision

April 27, 2005

Mr. William Adams, P.E.
Location Engineer
Alabama Department of Transportation
1409 Coliseum Boulevard
Montgomery, AL 36110-3050

Dear Mr. Adams:

Staff of the Appalachian Regional Commission (ARC) and our consultants, Economic Development Research Group (EDRG), are conducting a study to measure economic development benefits of Appalachian Development Highways. The ARC is working to develop an updated historical inventory of prior projects for this study and for future use in demonstrating impacts of these projects.

We need help from each state to accomplish these goals. We ask that your agency help us to complete information shown on the next page, summarizing information on Appalachian Development Highway sections in your state, including dates of construction of various highway sections, information on intersections and interchanges and traffic count data. The enclosed packet includes an information collection form, a set of instructions, and a sample completed form. The information collection form lists each county in your state that has been identified as having at least one Appalachian Development Highway section. If you believe that this list contains any errors, please note it on the form or contact us directly.

If you have any questions about this project, please feel free to call Greg Bischak of the Appalachian Regional Commission at (202) 884-7790. If you have any questions about how to complete this form, please contact Teresa Lynch of EDRG at (617) 338-6775, ext. 207. Completed forms can be returned by email to tlynch@edrgroup.com or by postal mail to EDRG, 2 Oliver St, 9th Floor, Boston MA 02114, attn: ADHS survey.

Thank you for your assistance.

Sincerely,

Kenneth Wester
ADHS Program Coordinator

1666 CONNECTICUT AVENUE, NW, SUITE 700 WASHINGTON, DC 20009-1068 (202) 884-7700 FAX (202) 884-7691

Alabama Georgia Kentucky Maryland Mississippi New York North Carolina Ohio Pennsylvania South Carolina Tennessee Virginia West Virginia

INFORMATION COLLECTION FORM
FOR DATABASE ON ADHS SEGMENTS

A. HIGHWAY SUMMARY

State:	*Alabama*
Appalachian Corridor:	*V, X*
US/State Highway #s:	*See attached map*

Counties Served (list):			
	Franklin	Marion	
	Jackson	Morgan	
	Jefferson	St. Clair	
	Lawrence	Walker	
	Limestone		
	Madison		

B. FORM COMPLETION

Name of person completing the form:		Telephone number:	
E-mail address:		Date of completion of the form:	

Instructions:

The next page contains a form that asks for information about the characteristics of Appalachian highway sections within each county. The characteristics are: year construction started; year highway section was opened to traffic; highway width (number of lanes) before and after construction; type of highway improvement (brand new ("NEW"); widening of existing highway ("WIDEN"); or replacement of existing highway, which is then retired ("REPLACE")); and number of interchanges and signalized intersections. For interchanges and signalized intersections, the actual number should be entered; however, if the number is greater than 10, you may enter "10+". In cases where different highway sections within a county have different dates of construction or opening dates, information should be provided for each section separately. You might also wish to report multiple sections within each county if different parts of the highway have different roadway characteristics and/or different traffic levels.

In addition, we would like available traffic counts (average daily traffic totals, 2-way) for section of the highway route, ideally covering periods before completion, shortly after completion and most recently available. You may enter the traffic counts and other information on this form or use your own sheets. Please note the location of the counts if they apply only to a particular part of a highway section.

To aid in completion of this form, we have included a sample completed form and where available, maps that show segments alignments and route numbers.

C. HIGHWAY CHARACTERISTICS

County Name	Section Description, if necessary	Date Construction Started	Date Open to Traffic	Type of Improve-ment	Section Length (miles)	#Hwy Lanes (Before /After)*	Access Type*	# Signalized Intersections	# Limited Access Inter-changes	Traffic Counts (ADT & year)
Franklin										
Jackson										
Jefferson										
Lawrence										
Limestone										
Madison										
Marion										
Morgan										
St. Clair										
Walker										

* *Highway Lanes: 2, 4, 6 or 2/4M=mixed 2 and 4; Access Type: L =Limited Access, O = Open Access, M = Mix of Open and Limited*

4 POPULATION BASE & ACCESS TO AIRPORTS

"Spatial Geography: Effects of Population Base and Airport Access"
by
Teresa Lynch, Tyler Comings and Glen Weisbrod
Economic Development Research Group

4.1 Introduction

This chapter describes findings from two related studies. One examines the impact of a county's population base on its business mix. The other examines how highway access to airports also affects business mix. These two studies differ from other studies discussed in this report in that they focus on identifying determinants of a county's business mix rather than its economic growth and well-being.

The motivation is to help identify the conditions necessary for pursuing growth paths that target various types of manufacturing, trade, services or other business sectors. In addition, these two research studies are intended to shed additional light on the role and importance of highway access in supporting economic growth.

A major element of both research studies is that they focus on examining the existence of "threshold" or other non-linear effects. In other words, it would be expected that some types of business require a minimum labor market or customer market in order to select a location for a new plant. Similarly, some types of business may require locations within a particular travel time to an airport, which must also be of a minimum size to provide sufficient scheduled service. Thus, the role of thresholds and non-linear responses becomes important.

4.2 (A) Population Base: Methodology

Measure of Business Mix. The first part of this study examines the relationship of a county's business concentration and mix to its scale of population base or market. This relationship can be particularly important in establishing how the viability of various growth strategies and target industries may differ depending on the county population base or the degree to which it is urban or rural.

For this study a dataset was used that provided year 2002 employment by 3-digit NAICS industry codes, for each of the 410 counties in the ARC region. A dataset prepared by IMPLAN was used because it provided measures of total employment including self-employed individuals and farm workers, who are not covered in County Business Patterns data. IMPLAN data are based predominantly on the REIS data, but has the advantage that it has values filled in for all industries in all counties, without the problem of missing (withheld) data which is common for many specific industries in small rural counties. Using this dataset, we define and calculate an indicator of relative business concentration:

Business Concentration (i,c) = Employment Share (i,c) * Attraction Ratio (i,c)

where:

Employment Share = Employment (i,c) / Employment (Σ i, c)

Attraction Ratio = Employment (Σ i, c) / Population (c)

and i = NAICS industry, Σ i = sum over all industries, c=county

which simplifies down to:

Business Concentration (i,c) = Employment (i,c) / Population (c)

The reason for constructing this composite measure of relative business concentration is to represent the combination of relative industry mix (represented by the Employment Share calculation) and relative industry attraction (represented by the Attraction Quotient). The Employment Share calculation is the numerator of the Location Quotient used in an earlier chapter to measure the economic base analysis of trade areas. However, instead of using the denominator of the Location Quotient (which represents national norms for industry mix), we make use of an Attraction Ratio which expresses industry employment per local population base.

The Attraction Ratio can reflect the extent to which a county has a greater level of employment in the given industry than would be expected given its population. A high ratio is generally interpreted as an indicator that the county is a business center for the given industry and has a net inflow of workers coming in from surrounding areas for that industry. On the converse side, a low Attraction Coefficient could would normally be interpreted as an indicator that the county is not a center of activity for that industry, though that may be due to many factors including a high a unemployment rate or a low labor force participation rate (e.g., a retirement area).

This per capita measure of business concentration nets out the effect of differences in county population size, so that a small county can in theory have a high concentration of a given industry just as easily as a large or populous county. By normalizing the business concentration in this way, we make it possible to analyze the role of population size in affecting the business concentration, while avoiding correlation between the two.

Alternative Travel-Time Based Definition of Population Base. An alternative definition of population base was also constructed in which we used ESRI's Geographic Information System to calculate the population base within a 30 or 40-minute drive time of the population-weighted center of each county. That concept utilizes a more sophisticated form of spatial analysis than simply measuring the population located within each county.

Unfortunately, preliminary analysis showed that this new measure actually had *less* power in predicting business concentration. The reason was that defining a county's trade area in this way fails to provide any leverage for distinguishing between (1) a county that is the center of activity in a multi-county region and (2) a fringe county that exports its workers and spending to the center of activity. In both cases, the 30 or 40-minute drive time from each county would include the others, so that they would all appear to have an equally large trade area. The simpler metric of total county population, it is actually more accurate in distinguishing counties that are a center of population and activity from those that are more rural and serve as feeders to the activity centers.

Modeling the effect of county population size. The analysis examines how the business concentration indicator for each industry differs by population level of the county (based on Year 2000 Census data). Two different techniques are used: (1) exploration of alternative regression functional forms, and (2) exploration of differences in the ratio among county population size groups.

The a priori assumption was that the ratio of employment over population for retail industries will stay generally constant as population increases. For specialized distribution and services industries, though, it would be expected that the ratio should increase with greater population base, as these industries are more sensitive to market size features. We would also expect those industries that thrive in rural areas—agriculture and mining—to be negatively affected by increases in population density.

The first technique involved using "curve estimation" to explore the relative significance and explanatory power of alternative functional forms for each industry. The slope of this regression at any given point will be the ratio of Business Concentration to population. Therefore, if a *linear model* fits the data best, then we can conclude that the Business Concentration changes directly as population increases. If a *quadratic model* is the best fit (wherein the sign of the coefficient of the quadratic term, $[\text{population}]^2$, is positive) then the Business Concentration grows faster as population increases; if the sign is negative then the ratio growth will slow down as population increases. Similarly, if the best fit is a *logarithmic model* than the Business Concentration growth will also slow down and stop growing as population increases. These sets of models were run separately for 52 industries. In addition, an analysis of *threshold effects* was conducted by breaking down this relationship by six distinct size classes.

4.3 (B) Population Base: Results

Regression Results. The results of these regressions are close to *a priori* expectations. Retail industries have linear and quadratic regressions that fit very closely. Service industries have mostly positive quadratic coefficients. Agricultural industries exhibit a logarithmic or quadratic (with a negative sign) relationship. The latter is not surprising since agricultural industries usually thrive in rural areas. Manufacturing industries exhibit results that are generally mixed and insignificant, indicating that they are less sensitive to scale of the population base than retails and service businesses.

The regressions results are shown in Exhibit 4-1 for those industries in which the model had statistically significant coefficients and an R^2 of 0.50 or better (indicating that the regression formula was explaining over 50% of the variance in the industry concentration measure.) Key findings are that:

- The business sectors with a *negative quadratic coefficient* have an aversion to counties with a larger population base. These are generally agricultural sectors.

- The business sectors with a *positive quadratic coefficient* show increasing growth of business concentration as population grows, though the point of inflection differs among industries. These are generally wholesale and retail trade sectors that have some market scale requirements.

- The business sectors that had a *logarithmic regression* fit best are those that have some minimum population size requirement but no additional growth in business concentration as population increases further. These are industries that process crops and livestock, and hence need access to a minimal labor force

- About half of all industries are *not listed* because there did not appear to be a statistically significant relationship between their concentration and county population in the regressions. They include mining, most manufacturing and freight transportation. For these industries, factors including the location of natural resources, topography and access to highway networks may be more important than just having a local population base. (Note that the role of access to highways is explored in the prior chapter, and highway access to airports is explored in a later part of this chapter.)

Exhibit 4-1 Business Concentration Regression Results for Selected Industries

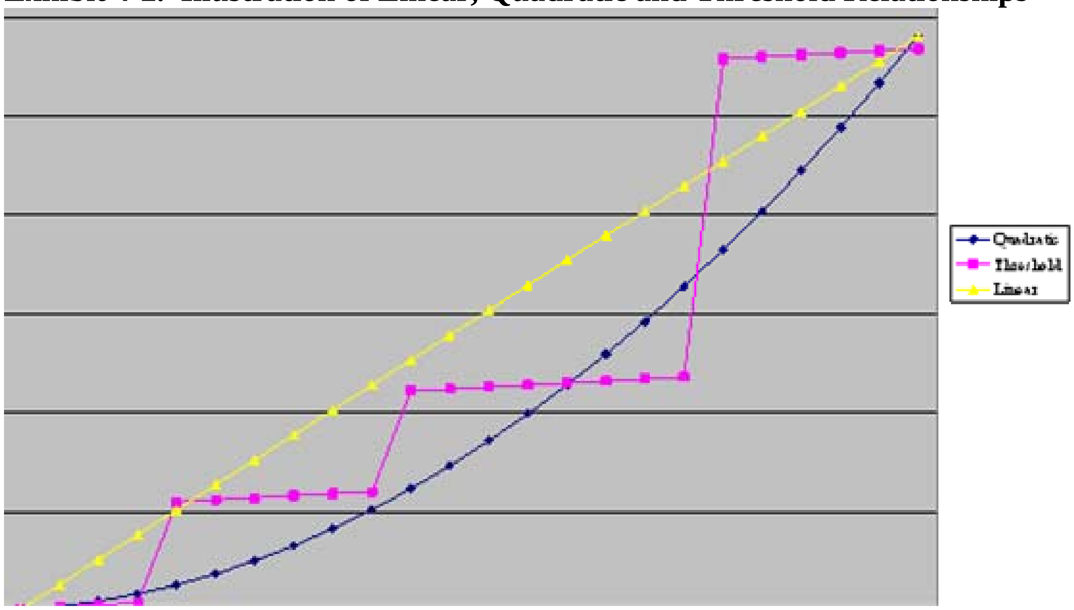
NAICS		Parameter Estimates		
		B1(Pop)*	B2(Pop^2)**	R^2
Quadratic w/ negative coefficient				
332	Fabricated metal prod	7933.4	-2200.	.66
447	Gasoline stations	5080.97	-2500.	.90
623	Nursing & residential care	12041.88	-6900.	.86
721	Accommodations	3313.56	-880.	.50
Quadratic w/ positive coefficient				
42	Wholesale Trade	7520.11	58500.	.91
92	Government & non NAICs	59961.5	34200.	.85
221	Utilities	1392.93	4150.	.53
230	Construction	25623.49	49400.	.94
323	Printing & Related	2268.82	2300.	.58
339	Miscellaneous mfg	1812.84	3560.	.63
441	Motor veh & parts dealers	7309.62	6050.	.96
442	Furniture & home furnishings	1459.61	2840.	.88
443	Electronics & appliances stores	1000.83	3450.	.87
444	Bldg materials & garden dealers	4180.55	4590.	.90
445	food & beverage stores	10155.42	5390.	.95
446	Health & personal care stores	3392.82	3140.	.95
448	Clothing & accessories stores	3156.62	9680.	.79
451	Sports- hobby- book & music stores	1819.98	4920.	.88
452	General merch stores	11004.37	4340.	.94
453	Misc retailers	4435.05	7810.	.91
454	Non-store retailers	4136.71	6150.	.62
484	Truck transportation	9186.41	2990.	.50
491	Postal service	1642.57	3830.	.79
492	Couriers & messengers	1371.51	3310.	.63
493	Warehousing & storage	1431.7	2030.	.63
511	Publishing industries	1523.2	4640.	.83
512	Motion picture & sound recording	278.92	1630.	.72
513	Broadcasting	539.11	21100.	.89
514	Internet & data process svcs	-97.03	4630.	.64
521	Monetary authorities	3367.09	13000.	.79
523	Securities & other financial	497.98	9000.	.77
524	Insurance carriers & related	907.77	35400.	.79
525	Funds- trusts & other finan	-340.7	2870.	,54
531	Real estate	6331.76	17000.	.85
532	Rental & leasing svcs	1857.06	5280.	.92
541	Professional- scientific & tech svcs	13221.38	67400.	.78
551	Management of companies	1378.15	11600.	.77
561	Admin support svcs	13487.54	67000.	.89
621	Ambulatory health care	16961.05	12000.	.89
622	Hospitals	12300.35	9430.	.67
711	Performing arts & spectator sports	1744.07	5000.	.90
713	Amusement- gambling & recreation	4060.41	1730.	.77
722	Food svcs & drinking places	32363.29	20600.	.95
811	Repair & maintenance	9138.55	15100.	.94
812	Personal & laundry svcs	4926.94	8330.	.90
Logarithmic				
111	Crop Farming	27.909197	--	.55
112	Livestock	36.6938123	--	.64

The independent variable is POP.
*actual coefficients multiplied by 1,000,000

**actual coefficients multiplied by 1,000,000,000,000

Concept of Thresholds. The strong finding that retail and service industries had non-linear relationships between industry concentration and population base indicates the likely presence of "threshold effects"—where a certain minimum population base is necessary to make a given industry viable and thus attracted to the area. Of course, the location and magnitude of this threshold effect may differ by industries. Exhibit 4-2 portrays this relationship by contrasting a linear relationship, a quadratic relationship and a threshold relationship (where multiple thresholds are shown).

Exhibit 4-2. Illustration of Linear, Quadratic and Threshold Relationships



It would be expected that threshold effects are particularly important for specialized business functions such as professional and financial services. That is, we expect the size of an area affects its ability to attract certain (generally high-skilled) sectors, either because these sectors require large numbers of potential customers or require specialized skills that are more easily found in larger labor markets.

To test this hypothesis, we calculated business concentration ratio for each 3-digit NAICS sector for the following county population sizes: <10,000, 10,000-24,999, 25,000-49,999, 50,000-99,999, 100,000-249,999, and >250,000. As shown in Exhibit 4-3, the industries that exhibit threshold effects can be categorized into two groups. In Group 1, Business Concentration (sector employment per capita) successively increases with county size, indicating that there may be increasing returns to increasing population base, and possibly also some threshold effects. In the Group 2, Business Concentration declines between county population size <10,000 and county population size 10,000-25,000, then increases with each increase in county population. This second group of industries may indicate that there are minimum requirements or scale effects at work that preclude those industries from locating in rural areas with a small population base.

Exhibit 4-3. Evaluation of Threshold Effects

% change in Business Concentration Ratio(Jobs-per-capita) from Previous (Smaller) Population Category

NAICS - Industry Sector		ARC County population					
		10,000-24,999	25,000-49,999	50,000-99,999	100,000-249,999	over 250,000	*TOTAL Growth*
Group 1: Positive growth across all size categories							
42	Wholesale Trade	85%	36%	38%	24%	71%	*640%*
230	Construction	26%	7%	22%	22%	27%	*153%*
441	Motor vehicle/parts dealers	54%	30%	28%	8%	5%	*190%*
442	Furniture stores	67%	35%	11%	38%	29%	*345%*
443	Electronic & appl. stores	117%	23%	35%	61%	76%	*919%*
445	food & beverage stores	21%	10%	5%	17%	4%	*70%*
446	Health & pers care stores	15%	10%	10%	14%	10%	*74%*
448	Clothing stores	77%	40%	39%	43%	56%	*670%*
451	Specialty stores	48%	30%	65%	59%	60%	*709%*
454	Non-store retailers	73%	9%	11%	9%	17%	*166%*
481	Air transportation	14%	48%	208%	223%	270%	*6108%*
485	Transit & ground passengers	88%	155%	2%	29%	18%	*647%*
511	Publishing industries	17%	9%	43%	47%	152%	*574%*
523	Securities & other financial	31%	12%	54%	125%	317%	*2031%*
524	Insurance carriers & related	19%	13%	67%	61%	139%	*767%*
541	Professional & tech. services	11%	52%	64%	31%	157%	*829%*
561	Admin support services	82%	51%	41%	36%	88%	*891%*
621	Ambulatory health care	26%	21%	23%	24%	29%	*204%*
622	Hospitals	73%	2%	33%	12%	17%	*208%*
722	Eating & drinking places	16%	36%	23%	15%	19%	*166%*
811	Repair & maintenance	40%	34%	31%	14%	30%	*265%*
812	Personal & laundry services	0%	48%	31%	27%	44%	*254%*
Group 2: Sectors with *Jobs-per-capita* growth at population levels of 25,000+							
92	Government etc.	-10%	11%	19%	15%	20%	*63%*
453	Misc retailers	-2%	16%	38%	20%	29%	*145%*
487	Sightseeing transportation	-50%	88%	31%	9%	122%	*195%*
514	Internet & data process svcs	-70%	17%	104%	208%	79%	*296%*
531	Real estate	-22%	40%	20%	41%	122%	*314%*
532	Rental & leasing svcs	-45%	39%	19%	12%	84%	*87%*
562	Waste mgmt & remediation	-3%	62%	1%	0%	28%	*102%*
711	Performing arts & sports	-62%	9%	15%	72%	113%	*76%*

The results in prior Exhibit 4-3 show that the Business Concentration Ratio in various both retail and specialized services is much higher in larger counties than in smaller counties. This may also reflect the growth of big box retailers that invest primarily in areas with some minimum population size threshold. It is particularly interesting to note some of the most dramatic threshold jumps:

- Growth in Transportation (NAICS 481) above 50,000 population,
- Growth in Financial Securities (NAICS 523) above 100,000 population,
- Growth in Publishing (NAICS 511) above 250,000 population,
- Growth in both Professional-Technical-Scientific Services (NAICS 541) as well as Insurance Offices (NAICS 524) above 250,000 population,
- Presence of Real Estate (NAICS 531) and Sightseeing Transportation (NAICS 487) starting at 25,000 population with an additional jump above 250,000

The various types of threshold relationships are shown graphically in Exhibits 4-4 through 4-6. Exhibit 4-4 illustrates the jump in professional and scientific services when the population exceeds 250,000. This finding makes sense as this kind of industry usually is found in very large population centers. This industry's functional form was quadratic with a positive coefficient which indicated that relative activity in this industry increased with population.

Exhibit 4-4. Threshold for Professional, Technical and Scientific Services

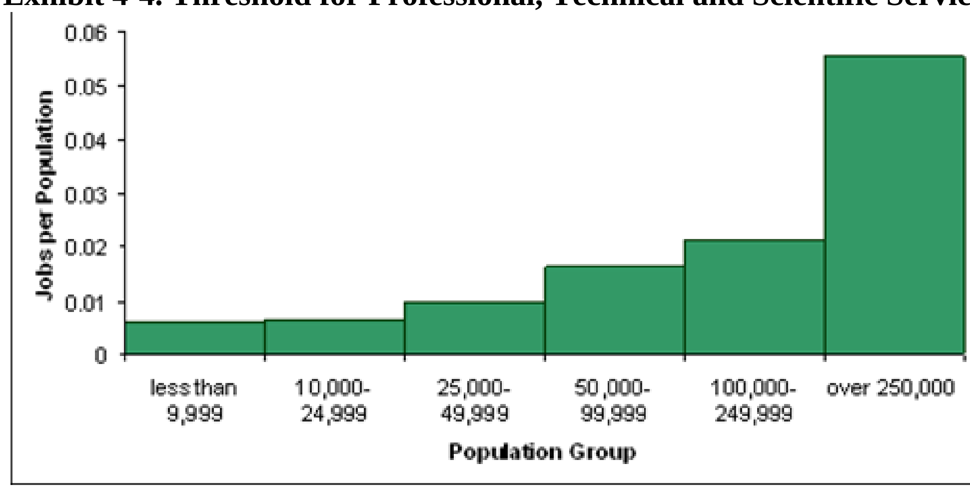


Exhibit 4-5 illustrates a pattern of continuing growth in business concentration as population increases. The functional form of the regression for this industry was quadratic with a negative coefficient which suggests that the rate of growth in activity peaks and then eventually tapers off as county population increases further.

Exhibit 4-5. Threshold for Ground Transportation

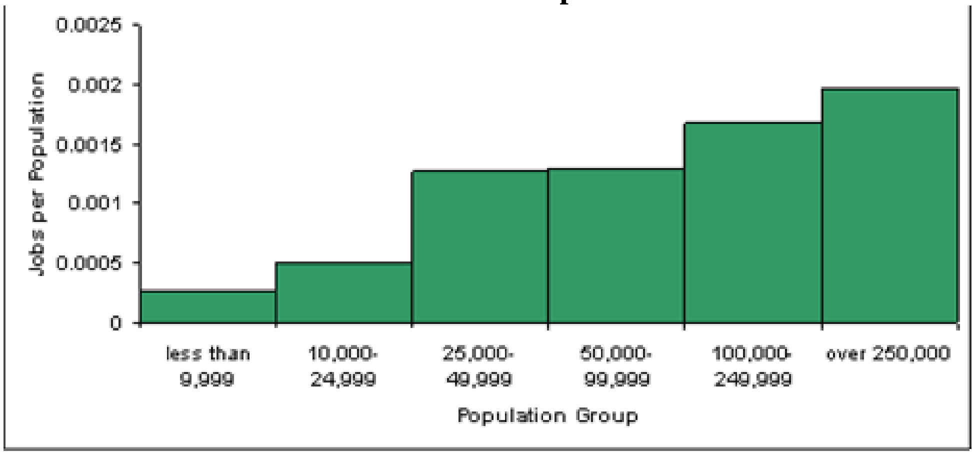
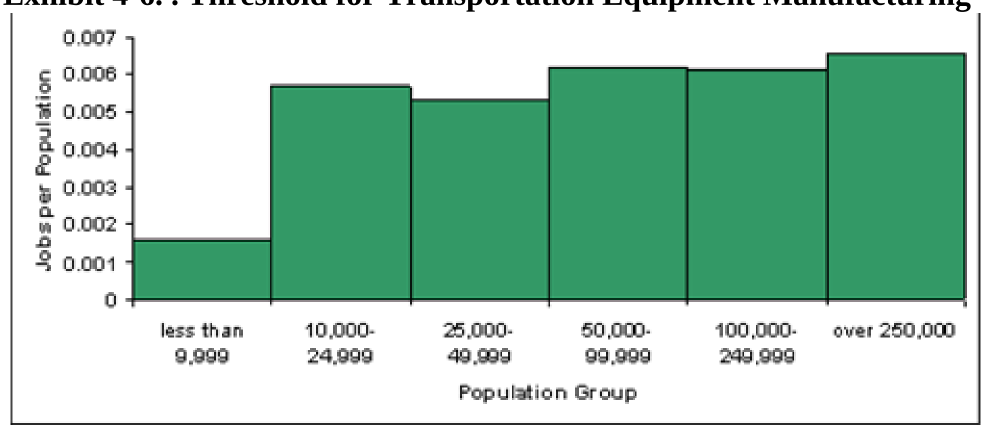


Exhibit 4-6 shows an example of the relationship for many manufacturing industries, which may require a minimum of around 10,000 population but do not appear to grow in Business Concentration as area population increases further. As previously noted, this type of business is often dispersed along supply chains and depends on transportation network connections rather than population size as a locational determinant. In fact, one of the motivations of a dispersed supply chain is that it allows use of parts suppliers located in lower cost and smaller labor markets.

Exhibit 4-6. . Threshold for Transportation Equipment Manufacturing



When comparing the regression results to the category-based threshold analysis, it was concluded that the latter form of analysis provided more precision. The regressions do give an indication of the type of relationship that employment-per-capita has for a given industry. However, they do not allow for precise identification of inflection points in a relationship that are due to minimum requirements for market or production scale economies. Further discussion of the use and limitations of this analysis, and directions for further research, are presented at the end of this chapter.

4.4 (B) Airport Access: Methodology

The second part of this study examines the relationship of a county's business mix to airport proximity, where both highway drive time to the airport and the size of airport service are considered. For some manufacturing industries that have national and international customers, airport access can be particularly important.

This analysis starts with the same dataset as the prior study of business concentration. It uses year 2002 employment by 3-digit NAICS industry codes, for each of the 410 counties in the ARC region. It was supplemented by comparable data for another 228 counties located outside of the ARC region, to enhance the coverage of outside metro centers. This data from IMPLAN represents total employment including self-employed individuals and farm workers, who are not covered in County Business Patterns. The study also used a Geographic Information System to calculate each county's population-weighted centroid, and the average drive time (in minutes) from that location to the closest airport with scheduled passenger service. Additional FAA data was used to represent the level of airport activity, represented as the number of commercial airline takeoffs and landings (known in the aviation field as "total operations").

It would be expected that industries that are more dependent on air transportation will seek locations convenient to an airport, and particularly locations convenient to an airport that is large enough to serve their needs. This may include businesses that rely on air service for incoming materials, customer visits, employee sales travel, or product delivery. In general, business sectors that are known to value air transportation include light manufacturing industries that rely on exporting and importing air cargo, and service industries that rely on employee business travel.

To estimate this relationship, each industry's share of total county-wide employment was calculated, and non-linear regression analysis was used to predict the roles of explanatory variables representing airport access time, airport size and the interaction of the two. There are several salient considerations that guided this specification:

- The measure of Employment Share was used to represent the relative portion of countywide employment each industry. This measure was used in order to focus on how airport access affects the *economic specialization* of counties. This measure was used instead of employment size or business concentration measures to avoid correlation with population size of the county, which is another factor analyzed separately in the preceding part of this chapter.

- The analysis of explanatory factors focused on interactions between airport size and airport distance or travel time in order to illuminate the role of highway connections in improving access for air-dependent industries.

- Various forms of "curve fitting" regression formulations were used to calculate the relationships and shape of curves. But unlike the preceding study of population base, there was no separate analysis of threshold effects for airport distance because many types of business value airport proximity but few if any would find additional value in being some minimum distance away.

The statistical analysis tested various linear, quadratic and logarithmic curve forms to explain the roles of airport size and ground access travel time on industry employment shares. They all generally involved three explanatory variables: size of airport(number of operations), distance to airport (access time), and the interaction between the two (number of operations*access time). The functional form for the linear model was:

$$\textit{Employment Share } (i,c) = B_1 * time(c) + B_2 * Size(c) + B_3 * [time(c) * size(c)$$

where i = NAICS industry and c=county

The statistical analysis also tested a "gravity model" formulation that represented the interaction between a positive weighting factor of airport size and a negative factor of airport access time (squared).

$$\textit{Employment Share } (i,c) = B_1 * time(c) \;/\; size^2(c)$$

4.5 (B) Airport Access: Results

Roles of Airport Access Time and Size. Results of the regressions can best be illustrated by showing how various industries respond differently to the effect of airport access time (holding airport size constant), and to the effect of airport size (holding airport access time constant). Accordingly, we present a pair of graphics for a typical county.

Exhibit 4-7 illustrates how the predicted number of jobs in a typical county would differ as *ground access time* to a typical size airport increases. It shows a steep drop-off of jobs in professional and technical services as airport access time increases from 1 to 80 minutes, with lesser impact beyond that point. The role of access time is significant but less dramatic for transportation equipment manufacturing and essentially non-existent for logging industries (which seldom use air travel).

Exhibit 4-8 illustrates how the predicted number of jobs would differ as *airport scale* (annual operations) increases. It shows a steep rise of jobs in professional and technical services as airport size rises above 50,000 annual commercial operations, tapering off as annual commercial operations increase beyond 100,000. The role of airport scale is significant but less dramatic for transportation equipment manufacturing (increasing most steeply as annual commercial operations rise to at least 10,000). Again, the role of airport size is essentially non-existent for logging industries (which seldom use air travel).

Exhibit 4-7. Effect of Ground Access Time to Airport

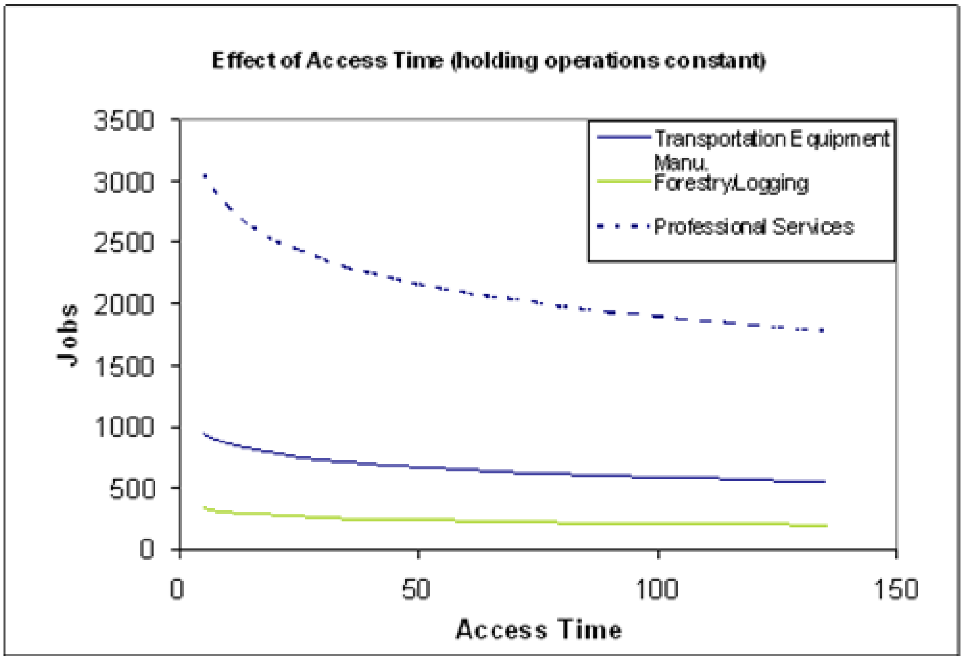
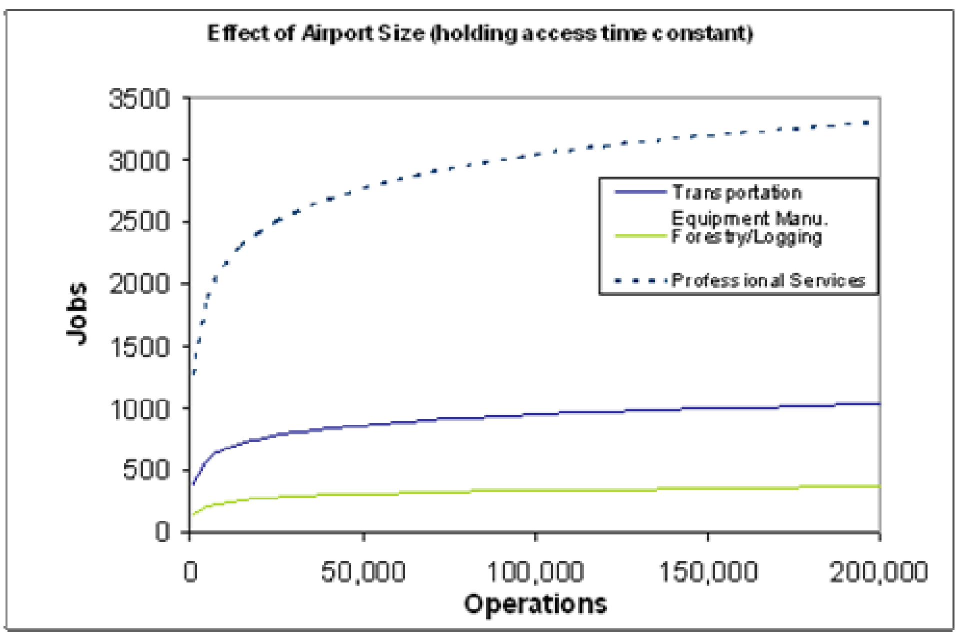


Exhibit 4-8. Effect of Airport Size



The regression coefficient estimates, shown in Exhibits 4-9 and 4-10, also show how some industries have a negative (or positive, diminishing) reaction to airport access and size. For instance, in Exhibit 4-9 the effects in agricultural industries have a positive coefficient for *time*. This means that they benefit from being further away from an airport. Other industries that have a significant positive coefficient for time include: mining, apparel manufacturing, and furniture manufacturing.

Some of those industries in Exhibit 4-9 that have a negative, significant coefficient for time (indicating that they value a reduction in airport travel time) are: wholesale trade, paper manufacturing, insurance, and professional services. These are the types of industries that we would expect to situate near airports, since they all rely on worker air travel for meetings with either clients or other office locations of their business. Exhibit 4-10 shows industries that have a positive but diminishing effect as airport access time decreases or operations increase. Some of these industries showed a negative effect in Exhibit 4-9 (i.e. crop production); this is due to the use of a different functional form. The estimates obtained for Exhibit 4-10 used a logarithmic model which gave many significant parameters estimates yet was not the best fit across all industries.

Testing of Urbanization Effect. We might expect these coefficients to also be affected by the degree of urbanization of a county. While the measure of Employment Share is standardized so that it is not affected directly by population size, it is known that some technology and service industries congregate in high population areas, as demonstrated in the preceding Population Base analysis. To see if this has an effect on the airport analysis, we tested whether the core model coefficients changed sign or significance when adding the "*urban effect.*" This effect was incorporated by adding a dummy variable for counties with population of 200,000 or more (Urban dummy = 1). All other counties were assigned a value of 0" representing non-urban areas.

The implications of adding a test of urbanization to Model #1 are embedded in Exhibit 4-9. The urban effect is categorized in the columns to the right of each independent variable: (A) represents cases where the urban dummy variable stays significant and has the same sign as the original variable, (B) represents cases where the original variable is insignificant but the urban variable is significant, and (C) represents cases where there is no significant urban effect; i.e., where the urban variable is not significant even though the original variable was significant.

The results show most of the effects lie in the "C" category. For the time variable, there is either no urban effect or adding the urban variable only makes the time variable insignificant—the exception being the wood products industry. For the size and interaction variables, there are several industries where the effect of these variables is reinforced in urban counties. These industries include: insurance, real estate, professional services, administrative services, and publishing. However, for most industries there seems to be no urban effect.

Exhibit 4-9. Regression Results for Airport Access Model #1
(shown for selected industries with statistically significant coefficients)

Sector		**B_1(Time)**		**B_2(Size)**		**B_3(Time*Size)**	
111	Crop Production	**181.38**	C	**-2981**	C	23.731	-
112	Animal Production	**210.41**	C	**-5443**	C	**69.797**	C
113	Forestry & Logging	**68.704**	C	-317.7	-	-2.519	-
115	Support for Agriculture & Forestry	-25.778	-	**-1649**	C	**34.547**	C
212-213	Mining & Support Activities	**281.68**	-	886.9	-	-25	-
230	Construction	-53.341	-	**3171.5**	C	-4.689	-
313	Textile Mills	1.162	-	-1654	-	**24.611**	C
315	Apparel Manufacturing	**60.604**	-	-959.2	-	11.457	-
321	Wood Products	120.15	B	**-1509**	-	10.069	-
322	Paper Manufacturing	**-38.529**	C	-601.9	-	4.229	-
324	Petroleum & Coal Products	**-6.944**	C	-45.09	-	0.262	-
325	Chemical Manufacturing	**-44.866**	C	-577.6	-	3.71	-
336	Transportation Equipment	-1.818	-	**-1558**	-	16.915	-
337	Furniture & Related Products	**104.76**	-	-929.2	-	8.37	-
420	Wholesale Trade	**-85.13**	C	**3051.8**	C	**-32.57**	C
441-454	Retail Trade	-53.926	-	-348.1	-	0.209	-
491-493	Mail, package delivery & warehousing	**-51.904**	C	636.49	-	-8.7	-
511	Publishing Industries (except Internet)	-7.676	-	**595.39**	A	**-7.997**	A
512	Motion Picture & Sound Recording	**-4.165**	C	**248.7**	C	**-2.874**	C
513	Broadcasting	-1.182	-	**1345.2**	C	**-18.366**	C
514	Internet & data process svcs	-3.325	-	**595.67**	C	**-8.048**	C
524	Insurance Carriers & Related Activities	**-39.451**	C	**1145.7**	A	**-15.307**	A
525	Funds, Trusts, & Financial	1.755	-	**335.42**	A	**-4.53**	C
531	Real Estate	-28.396	-	**2846.1**	A	**-31.769**	A
532	Rental & Leasing Services	4.199	-	**449.11**	A	**-6.451**	C
541-551	Prof. Scientific, Technical, Services	**-176.12**	C	**7735.9**	A	**-93.673**	A
561	Administrative & Support Services	**-147.74**	C	**4584**	A	**-46.247**	A
711-713	Amusement & Recreation	**-49.522**	C	**1569.8**	C	**-17.369**	C
721-722	Accommodations, Eating & Drinking	**-124.69**	C	**1887.8**	C	-18.107	-
811-812	Repair, Maint, Personal Services	**-84.957**	C	**1428.1**	C	**-11.626**	C
814	Government	58.482	-	**-2413**	-	**37.496**	C

***bold** indicates that coefficient is statistically significant*
***A**=urban variable reinforces effect*
***B**=only an urban effect*
***C**=no urban effect when variable is already significant*
"-"=no significant effect in either case or incorrect sign

Exhibit 4-10. Regression Results for Airport Access Model #2
(shown for selected industries with statistically significant coefficients)

NAICS	Industry	Parameter Estimates b1(ln(oper/time))
111	Crop Production	**0.003992**
112	Animal Production	**0.004882**
113	Forestry & Logging	**0.00068**
115	Support for Agriculture & Forestry	**0.000756**
212-213	Mining & Support Activities	**0.001431**
230	Construction	**0.010472**
313	Textile Mills	**0.001388**
315	Apparel Manufacturing	**0.001057**
321	Wood Products	**0.001964**
322	Paper Manufacturing	**0.000789**
325	Chemical Manufacturing	**0.00091**
336	Transportation Equipment	**0.001901**
337	Furniture & Related Products	**0.001897**
420	Wholesale Trade	**0.004073**
441-454	Retail Trade	0.018785
491-493	Mail, package delivery & warehousing	**0.001503**
511	Publishing Industries (except Internet)	**0.000559**
512	Motion Picture & Sound Recording	**0.000142**
513	Broadcasting	**0.001072**
514	Internet & data process svcs	**0.000224**
524	Insurance Carriers & Related Activities	**0.001345**
531	Real Estate	**0.00256**
532	Rental & Leasing Services	**0.000731**
541-551	Professional Scientific, Technical, Services	**0.006102**
561	Administrative & Support Services	**0.004967**
711-713	Amusement & Recreation	**0.002314**
721-722	Accommodations, Eating & Drinking	**0.010516**
814	Government & non NAICs	**0.00226**

Note: ***bold*** *coefficients are statistically significant*

4.6 Uses and Limitations of the Findings

The findings shown in this chapter can be directly embedded in the Local Economic Assessment Package which ARC provides to its Local Development Districts. The findings on threshold effects associated with local population base can be used to identify likelihood of attracting various industries to a local area. The findings on the role of access time and facility service level factors on business attraction can be incorporated in the diagnosis of barriers associated with insufficient access to airport services. At the time of this publication, these improvements have already been made to the LEAP model.

There are, however, clear ways in which this line of analysis can be improved. There is a need to explore whether or not a measure of trade center strength, such as the spatial multiplier used in the Chapter 2 study, may be as good or better than the current population base as a predictor of market area strength for attracting retail, wholesale and related service businesses. There is also need for further analysis of the business attraction relationship to airport access – separating improvements in access time, distance, type of highway access and/or airport service levels. Finally, there is a need to further explore the ways in which the impacts of market scale and airport access features may be better measured in terms of industry employment shares, concentration ratios or total size of the industries.

5 SPATIAL INFLUENCES IN COUNTY ECONOMIC PERFORMANCE

This chapter is extracted and edited from the original document:
"Task 1, Part 4: Empirical Analysis""
by
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Massachusetts Institute of Technology

5.1 Introduction

To better understanding what causes some non-metro Appalachian counties to make economic strides forward, while others remain distressed, a set of empirical studies were conducted with the aim of elucidating the role exerted by economic areas linked to a county. Our objective here is to (a) identify the nature of that linkages among counties, (b) define the geographic extent and features (contiguous/ non-contiguous) of this spatial neighborhood, (c) assess the roles of mountain topography, market access and highway links in affecting those results, and (d) identify how these factors affect levels of economic distress and changes in those levels over time.

In this section, we present an exploratory analysis of the factors affecting the current economic conditions and trends in Appalachia's non-metropolitan (non-metro) counties. We extract four types of variables that we consider to be closely related to the USDA/ERS typology of Appalachian Region counties, because regional analysts generally consider county type to play a significant role in determining county economic performance. We explore the statistical features and spatial patterns of the variables using statistical software and mapping and spatial analysis tools available in ArcGIS, geographic information systems, SPSS statistical analysis software and GeoDa, spatial statistics software developed by the Spatial Analysis Laboratory (SAL) in the Geography Department at the University of Illinois, Urbana-Champaign.

5.2 Exploratory Statistical Analysis

The analysis conducted for this study focused on the development of various forms of regression models to assess the role of explanatory factors in explaining and predicting patterns and trends in the economic well-being of non-metro Appalachian counties. Specifically, the types of county data that we use include:

Dependent variables:

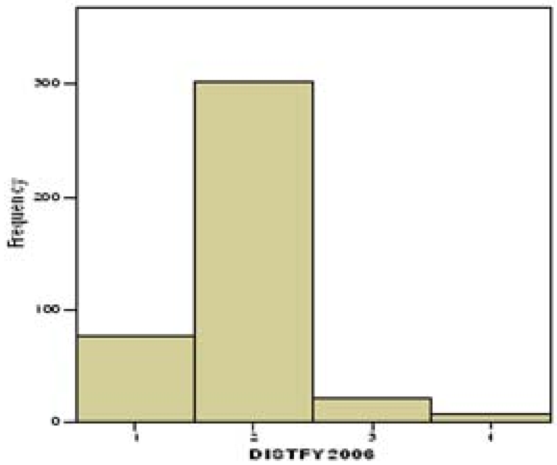
- ***Measures of economic health***: As a dependent variable, to be explained through the empirical analysis, we examine several measures (current levels or growth change) of each county's economic health. One key measure is the ARC county economic-status classification, whereby counties are classified a "attainment," "competitive," "transitional," or "'distressed" for each (fiscal) year. This classification is based on employment, income, and poverty measures (relative to the US average). The "Pickard Index" combines the three measures into a single, continuous index of economic level. In order to distinguish these two variables, we name the four-level, categorical variable as the ARC county Economic Status Class (ESC), and the continuous variable (the Pickard Index) as the county Economic Level Index (ELI). Another measure of economic health that we utilize is the county employment *growth* between 1990 and 2000, adjusted (using shift-share analysis) to control for national trends. This measure is obtained from IMPLAN based on Bureau of Economic Analysis and their Regional Economic Information System.
- ***Change in economic health:*** We assess patterns of change over time in terms of (a) the rate of growth or decline in the ELI rating, and (b) the rate of employment growth rate in the county as a whole.

Independent (explanatory) variables:

- ***Demographic data***: US Census demographic data from 2000 for such variables as the age, education, minority status, mobility, and urban/rural residential location of the county population,
- ***Geographic characteristics***: terrain, elevation, natural amenity, and highway data describing the geographic features and transportation infrastructure of the counties. The terrain and elevation data are from the US Geological Survey (USGS), the transportation data are from ARC and the US Department of Transportation's Bureau of Transportation Statistics. The natural amenity scale is an index of the density of attractiveness of geographic features developed by the Economic Research Service (ERS) of the United State Department of Agriculture (USDA)
- ***Industrial mix and commuting patterns:*** measures of industrial mix, types and business, and commuting patterns within the Appalachian counties. BEA/REIS data break down earned income by industry for 1980, 1990, and 2000. We also develop entrepreneurship indicators from BEA/REIS data on the diversity and value-added components of earned income. Commuting patterns are based on 1990 US Census ''journey-to-work' data.
- ***Density and Urban Influence:*** measures of population density and urbanization for each county and for sub-county regions. These indicators include USDA/ERS measures of population-based rural-urban continuum codes and urban-influence codes; and the delineation of metropolitan and micropolitan areas.

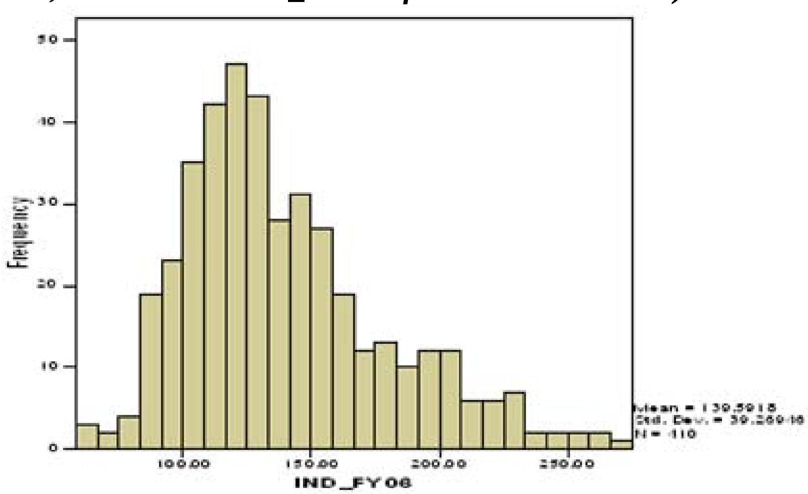
Exhibit 5-1 shows the frequency distributions of ARC's Economic Status Classes (ESC). Exhibit 5-2 plots the frequency distribution of the ELI index. The ELI measure (labeled IND_FY06 for Fiscal Year 2006) is a continuous function of the three measures (unemployment, income, and poverty) used to determine the ESC category. Compared with the four discrete ESC categories, the continuous ELI variable provides more differentiation among counties and, hence, an increased opportunity to explain variations in economic health across counties in terms of the independent variables that we have identified.

Exhibit 5-1: Distribution of County Economic Status Class (ESC)
(Labeled as "DISTFY2006")



Source: ARC's Economic Status Classification.

Exhibit 5-2: Distribution of the county Economic Level Index
(ELI, Labeled as "IND_FY06" for Fiscal Year 2006)



5.3 Models to Predict County Economic Level

A number of researchers have used econometric methods to model economic health (at county levels) as a function of various demographic and socio-economic factors, and industrial mix. However, relatively little work has been done to understand how geography and transportation infrastructure affect the interaction among counties and population centers and, as a result, the pattern and pace of economic development.

We focus our efforts on investigating measures of geographic and infrastructure features that might influence economic health through facilitating, or hindering, the interconnectedness of Appalachian counties – and the resulting speed at which economic growth might occur. GeoDa software allows us not only to run classic ordinary least-squares (OLS) regression models, but also to estimate "spatial-lag" and "spatial-error" regression models that account for additional spatial "spillover" effects that reflect the influence of economic neighbors.

Explanatory Variables. In order to see how much of the variation in ELI across the Appalachian counties can be explained by demographic, geographic, and market segmentation factors, we begin with the following set of measures for various factors that the literature suggests are correlated with economic health. Listed below are the basic explanatory variables used in regression models to predict county ELI levels.

Demographics	
PCTHSGRAD	Percentage of people with high school diploma
PER_MINORI	Percentage of people who are minority
PER_POP65P	Percentage of people over 65 years old
Mobility	
PCTSAMCNT	Percentage of people who resided in the same county 5 years earlier
Amenities	
ASCALE	Natural amenity scale
Entrepreneurship	
BREADTH	Economic breadth = # non-farm proprietors / total non-farm emp
DEPTHINC2	Non-farm proprietor income/# non-farm proprietors
DEPTHVALAD	Non-farm proprietor income, BEA/non-employer receipts
Industrial mix	
AGRIC00	Percentage of income from agriculture in 2000
MIN00	Percentage of income from mining in 2000
CNSTR00	Percentage of income from construction in 2000
MANFC00	Percentage of income from manufacturing in 2000
TRNSP00	Percentage of income from transportation in 2000
WHTRD00	Percentage of income from wholesale trade in 2000
RETRD00	Percentage of income from retail trade in 2000
FIRE00	Percentage of income from finance, insurance, real estate in 2000
SERV00	Percentage of income from services in 2000
GOV00	Percentage of income from government employment in 2000
County interdependence	
RADJ97_EMP	Income adjustment to account for workers' county of residence

(normalized by employment)

In this section, we develop two basic forms of regression model. The first one estimates the role of various county attributes (previously listed) on the Economic Level index (ELI) of each ARC county as of FY2006. The second one adds geography and infrastructure factors to increase explanatory power. For both forms of regression model, a set of four variations is estimated. (Additional regression models of *changes* in county economic health are discussed in the section which follows.)

Exhibit 5-3 summarizes results for the first set of regression models under three different formulations: Ordinary Least Squares, Spatial Lag and Spatial Error. Findings from each of these model variations are summarized below:

Model 1-A. Ordinary Least Squares Regression. Using GeoDa softrware, the ELI rating of each county was regressed onto each of the 18 variables. The R-squared of 0.71 indicates that a linear combination of the independent variables explains 71% of the variance in ELI across counties – a modestly good fit. Most estimated coefficients have the expected sign. For example, the coefficient for education (PCTHSGRAD) implies a predicted decrease of 2.32 in the ELI indicator (i.e., an improvement in economic health because ELI measures the extent of poverty and unemployment) for every percentage point increase in the county's adults who have at least a high school graduate level of education. One other demographic variable was highly significant (with a positive relationship), the percentage of the population who are minority (PER_MINORI). The mobility indicator (PCTSAMCNT) was also significant. This measure is the percentage of persons who lived in the same county five years earlier. High values suggest an immobile population. Both these variables had positive signs indicating that higher percentages were correlated with higher ELI values –i.e. distressed economic conditions.

The ASCALE index measures the quantity and quality of scenic natural features and recreation areas in each county. It was not statistically significant as an explanatory factor. It could be that the economic benefits of natural amenities are accrued not so much by the county in which they reside, but by particular, proximate counties that are key points of access to the amenities, e.g., the valley along a major highway connecting population centers to scenic mountains and national parks. Likewise, the mere presence of a natural amenity does not imply that the county or proximate counties are able to leverage their assets into a thriving tourism economy.

The three entrepreneurship measures show mixed results. The breadth of proprietorship measure (BREADTH) is not significantly different from zero, and the two proprietorship "depth" measures (DEPTHINC2 and DEPTHVALAD) are significant but have opposite signs. Increases in DEPTHINC2 are associated with improved economic health (lower IND_FY06) and increases in DEPTHVALAD are associated with declines in economic health (higher IND_FY06). The standardized beta coefficients indicate that their effects are opposite in sign.

Exhibit 5-3: Coefficient Comparison of MODEL-1 Statistical Variations

	Model 1-A (OLS)			Model 1-B (Spatial Lag)			Model 1-C (Spatial Error)		
Variable	Coeff.	T-Stat	Prob.	Coeff.	Z-Val.	Prob.	Coeff.	Z-Val.	Prob.
CONSTANT	**246.707**	**10.346**	**0.000**	**156.208**	**24.141**	**.0000**	**302.088**	**11.998**	**0.000**
PCTHSGRAD	**-2.326**	**-14.528**	**0.000**	**-1.629**	**0.169**	**0.000**	**-2.636**	**-13.082**	**0.000**
PER_MINORI	**0.555**	**5.198**	**0.000**	**0.513**	**0.094**	**0.000**	**0.507**	**3.901**	**0.000**
PER_POP65P	-0.615	-1.172	0.242	0.004	0.461	0.993	0.387	0.768	0.442
PCTSAMCNT_	**1.374**	**5.800**	**0.000**	**1.078**	**0.208**	**0.000**	**0.696**	**3.089**	**0.002**
ASCALE	-1.338	-1.243	0.215	-0.302	0.948	0.750	0.560	0.523	0.601
BREADTH	-8.386	-0.476	0.634	5.057	15.508	0.744	-2.680	-0.180	0.857
DEPTHINC2	**-2.399**	**-5.865**	**0.000**	**-1.674**	**0.368**	**0.000**	**-1.631**	**-4.182**	**0.000**
DEPTHVALAD	**71.183**	**4.958**	**0.000**	**42.311**	**12.948**	**0.001**	**42.494**	**3.042**	**0.002**
RADJ97_EMP	**-0.682**	**-3.440**	**0.001**	**-0.389**	**0.176**	**0.027**	**-0.411**	**-2.453**	**0.014**
AGRIC00	-297.529	-1.385	0.167	-493.950	188.851	0.009	**-482.146**	**-2.861**	**0.004**
MIN00	-7.076	-0.397	0.691	-9.769	15.634	0.532	-6.054	-0.355	0.723
CNSTR00	-63.832	-1.768	0.078	-69.330	31.674	0.029	-50.697	-1.631	0.103
MANFC00	**-79.504**	**-7.133**	**0.000**	**-61.381**	**9.890**	**0.000**	**-52.132**	**-5.346**	**0.000**
TRNSP00	-37.585	-1.379	0.169	-39.687	23.914	0.097	-52.058	-2.368	0.018
WHTRD00	**-154.474**	**-2.825**	**0.005**	**-150.903**	**47.999**	**0.002**	**-105.494**	**-2.312**	**0.021**
RETRD00	34.988	0.899	0.369	1.825	34.172	0.957	-10.766	-0.346	0.729
FIRE00	-115.927	-1.617	0.107	-102.956	62.869	0.102	-82.349	-1.387	0.165
SERV00	**-45.419**	**-2.558**	**0.011**	**-46.495**	**15.577**	**0.003**	**-32.775**	**-2.158**	**0.031**
LAMBDA							**0.647**	**13.998**	**0.000**
Log-likelihod		-1823			-1786			-1777	
R-Squared		71.0%			77.6%			80.1%	

Dependent variable is the economic level index for FY2006 (ind_fy06).
Coefficients significant at the 0.05 level or better are in bold face.

Source: MIT-DUSP ARC Research Team.

Three of the nine industrial mix variables in MODEL-1A were statistically significant. They are manufacturing, wholesale trade, and services. All three have coefficients with negative signs indicating that sector size increases are associated with reductions in ELI scores which represent improvements economic well-being. The industrial mix coefficients are larger than those for the demographic variables, but that is because the industrial mix measures are fractions ranging from zero to 1.0 while the demographic factors range from 0 to 100%. The standardized coefficients adjust for differences in measurement units and show the much weaker effect.

The negative residential income adjustment (RADJ97_EMP) coefficient indicates that a county is better off (lower IND_FY06) if its residents bring in more wage income from out-of-county than the county's non-resident workers export to their home counties. This is one type of "spatial multiplier" effect whereby counties tend to have improved ELI scores if they experience net gains when earned income accounting is shifted from place of work to place of residence. That is, earned income tends to be spent closer to one's home than to one's workplace, so counties gain an economic stimulus if they house more out-commuters than they employ non-resident workers.

Model 1-B: Spatial-lag Regression. This model regresses ELI on the same 18 variables as before, but now using a "spatial-lag model." That type of regression model assumes that the value of an independent variable in one county spills over to affect the corresponding values in adjacent counties (Anselin, 2003). The model is a weighted regression where the weights are non-zero for counties that are adjacent to one another and the coefficients are estimated using maximum likelihood estimation.

The likelihood ratio test indicates that accounting for spatial-lag is worthwhile, and the effective R-squared increases to 78%. We are not surprised that the estimated coefficients for the most significant variables are somewhat reduced in the spatial lag model. For example, consider the education effect. Spillover effects from better education in neighboring counties could account for what otherwise might be lumped into a larger same-county coefficient in the ordinary least squares regression.

One change is that the size of the agricultural sector (AGRIC00) is now significant, and inverse in its effect, which is counterintuitive. A separate histogram shows that this variable is highly skewed with most values at or near zero and a right tail reaching only to 3 %. We would be better off treating AGRIC00 as a dummy variable indicating which counties had a measurably large agricultural sector.

Model 1-C: Spatial-Error Regression. This model regresses ELI on the same 18 variables as before, but now using "a spatial-error model" in place of the spatial-lag model. The "spatial-error" regression model assumes that the county-to-county spillover occurs indirectly through spatial correlation in the error terms for neighboring counties. That is, the independent variables have only local effects, but factors missing from the model specification are spatially correlated.

The signs and significant variables for the spatial-error model are similar to those for the spatial lag, although the residential persistence variable (pctsamcnt) is now marginal and the transportation sector size becomes significant. Overall, the log-likelihood is slightly higher and the effective R-squared is increased slightly (to 80%).

Both the spatial lag and spatial error runs use simple measures of proximity – spillover effects are assumed to come exclusively from neighboring counties and each adjacent county contributes in the same manner. Even with these simple assumptions, we see evidence of significant spillover effects. The RADJ97_EMP variable adjusts income earned by workers in a county in order to account for the county of residence of the employee. The fact that the RADJ97_EMP (expressed on a per-employee basis) is significant in the OLS regression indicates that income earned elsewhere can matter. The variable is less significant with a much smaller coefficient in the spatial lag and spatial error models, because some of the county-to-county influence is explicitly captured in the spatial lag or spatial error term.

Model 1-D. Consolidating the Industrial Mix. The industry specific variables in all of the preceding models had "multicollinearity" (meaning that a high share of employment in any one industry would tend to bring a lower share of employment in other industries). That makes their coefficient estimates subject to error. To address that, we used *factor analysis* to identify linear combinations of industrial sector percentages that capture most of the variation across counties.

Exhibit 5-4 show the component score coefficients for the extracted factors. For example, a county's 2000 factor score for Factor 1 would be computed by multiplying the coefficients in the Factor 1 column by the corresponding industry mix percentages for agriculture, mining, construction, etc. We see that Factor 1 has a large negative coefficient for manufacturing and large positive coefficients for wholesale and retail trade, fire, and services. So, counties with a high share of employment in services or trade and little manufacturing (relative to the other ARC counties) will have a high score on Factor 1. Alternatively, Factor 2 deemphasizes manufacturing and emphasizes mining, government, and transportation. So, counties with a high share of employment in mining and government, and little in manufacturing and wholesale will have a high score on Factor 2. Similarly, Factor 3 emphasizes government, agriculture, and construction without wholesale trade; and Factor 4 emphasizes construction, transportation, agriculture without government, or services.

Exhibit 5-5 (left side) shows the results of rerunning Model-1C (the spatial error model) with the four composite industry factors substituted in place of the nine industrial sector percentages (labeled as Model 1-D). We see that the fit is slightly better than before, with five fewer variables. Note that the most significant factor among the four is Factor-2 (which is higher where there is more reliance on mining or government activities and less on manufacturing or wholesale trade activities). The large positive coefficient (7.75) indicates that a one standard deviation increase in a county's Factor-2 value correlates with a 7.75 point increase (that is, diminished economic condition) in the ELI score for that county.

Exhibit 5-4, Factor Analysis Results
(Component Score Coefficient Matrix)

	Component			
	Factor-1	Factor-2	Factor-3	Factor-4
agric00	.107	-.031	.443	.519
min00	-.168	.260	-.201	.359
cnstr00	.191	.005	.494	.233
manfc00	-.148	-.472	-.041	-.113
trnsp00	.002	.168	-.401	.433
whtrd00	.264	-.210	-.234	.200
retrd00	.295	.075	-.053	-.331
fire00	.358	-.005	-.035	-.061
serv00	.292	.162	-.218	-.083
gov00	-.099	.365	.278	-.340

Factor Interpretation:
Factor-1: service/trade without manufacturing
Factor-2: mining/government without manufacturing/wholesale
Factor-3: government/agriculture/construction without wholesale trade
Factor-4: construction/transportation/agriculture without government/services

Exhibit 5-5: Coefficient Comparison for Models Using Industry Factors

	Model 1-D (spatial error model using industry factors)			Model 1-E (commuting shed model using industry factors)		
Variable	**Coeff.**	**Z-Val.**	**Prob.**	**Coeff.**	**Z-Val.**	**Prob.**
CONSTANT	**243.932**	**9.425**	**0.000**	**268.711**	**10.030**	**0.000**
PCTHSGRAD	**-2.534**	**-13.048**	**0.000**	**-2.781**	**-14.409**	**0.000**
PER_MINORI	**0.443**	**3.683**	**0.000**	**0.616**	**5.370**	**0.000**
PER_POP65P	0.291	0.609	0.542	0.740	1.593	0.111
PCTSAMCNT_	**0.904**	**4.159**	**0.000**	**0.608**	**2.807**	**0.005**
ASCALE	0.577	0.552	0.581	1.376	1.411	0.158
BREADTH	3.227	0.227	0.820	16.695	1.207	0.227
DEPTHINC2	**-1.306**	**-3.470**	**0.001**	**-1.017**	**-2.752**	**0.006**
DEPTHVALAD	**33.612**	**2.486**	**0.013**	**28.460**	**2.125**	**0.034**
FAC1_2000	**-4.173**	**-3.582**	**0.000**	**-4.403**	**-3.827**	**0.000**
FAC2_2000	**7.753**	**6.992**	**0.000**	**6.495**	**5.605**	**0.000**
FAC3_2000	1.639	1.591	0.112	1.279	1.275	0.202
FAC4_2000	**-3.487**	**-3.884**	**0.000**	**-3.317**	**-3.798**	**0.000**
RADJ97_EMP	**-0.507**	**-3.120**	**0.002**	**-0.356**	**-2.270**	**0.023**
LAMBDA	**0.625**	**13.066**	**0.000**	**0.900**	**109.477**	**0.000**
Log-likelihod	-1769			-1754		
R-Squared	80.7%			80.0%		

Model 1-E. Alternative Measures of County Connectivity – Commuting Zones. Both the spatial-lag and spatial-error models presented so far employ a simple notion of spillover, which assumes that each county is only affected by its "nearest neighbors" – with equal weight given to each neighbor. Given the mountainous terrain over much of Appalachia, we might expect that hills, rivers, interstates, and other major obstacles, and convenient infrastructure, could distort the meaning of "adjacency." For example, counties with highly inter-connected development paths might be those along a major interstate running through a valley.

The economic interdependence of counties can amplify the beneficial impact of economic development. If we know how counties are interdependent, then we can devise more effective economic development strategies. Prior versions of Model 1 provided some evidence of significant spillover effects among immediately adjacent counties. The best way to measure county connectivity is likely to depend on the type of development being considered. Analysts who use traditional economic growth models focus on residence/workplace linkages, and they might use commute-sheds to identify well-connected counties. But we envision other development strategies that may use a different notion of connectivity. Consider, for example, asset-based development, such as tourism or mining. In such cases, connectivity and interdependence might involve convenient highway and rail infrastructure connecting the local site to population centers or resource users. Alternatively, a knowledge-based development strategy may require an understanding of alumni networks and university connections. For example, the zip code frequency for home addresses of university students may be a good measure of where a university's education and technology transfer efforts are most likely to be felt.

To explore the usefulness of alternative connectivity measurement beyond "adjacency," we examine the commute-sheds (or commute-zones) for Appalachian counties. The USDA has developed commute-shed data for Appalachia based on US Census Bureau Year 2000 journey-to-work data. Each of the 410 counties is clustered into a commute-shed with other counties that most often share commuters who work in one county and live in the other. GeoDa software can use "commute sheds" to calibrate spatial weights that offer an alternative to the "adjacent county" approach.

Exhibit 5-5 (Model 1-E) shows the results of rerunning the prior model with spatial weights based on the commute-sheds, rather than on county adjacency. The results show little change in the model's explanatory power. Given the significant overlap of commute-sheds and "nearest neighbor" adjacent counties, we are not surprised that the results are similar for these two ways of identifying proximate counties that have intertwined economies. Also, the commute-shed results would probably be improved if we included counties at the edge of Appalachia that fall within commute-sheds that include one or more Appalachian counties.

Model 2-A and 2-B: Adding Geography and Access Factors. The final variation of the economic health models adds considerations of terrain slope, road density and worker accessibility.

- *Terrain Ruggedness – Slope Computations.* Because much of Appalachia is mountainous terrain, we might expect that hills, rivers, interstates, and other major obstacles (and convenient infrastructure) could warp the meaning of "connectedness" to be quite different from "as the crow flies." To investigate such possibilities, we computed a measure of terrain ruggedness based on slope computations. We obtained USGS elevation data, projected it to the Alber's area-preserving coordinate system used by ARC, and then converted it to a raster-elevation model in ArcGIS. We overlaid the grid cell slope (rise/run) estimates with the county boundaries, to estimate average slopes within each county (variable name SLOPE).

- *Nearby Terrain Slopes.* We also computed average slopes for all counties whose centroid fell within 66 kilometers of the target county (variable name SLOPE66). Exhibit 5-6 is a thematic map of the estimated slope of the Appalachian Region with lighter colors indicating locations with steeper slopes. Note the sharp change between the Cumberland Plateau and the Great Smoky Mountains where the Tennessee River Valley corridor runs Northeast and Southwest of Knoxville.

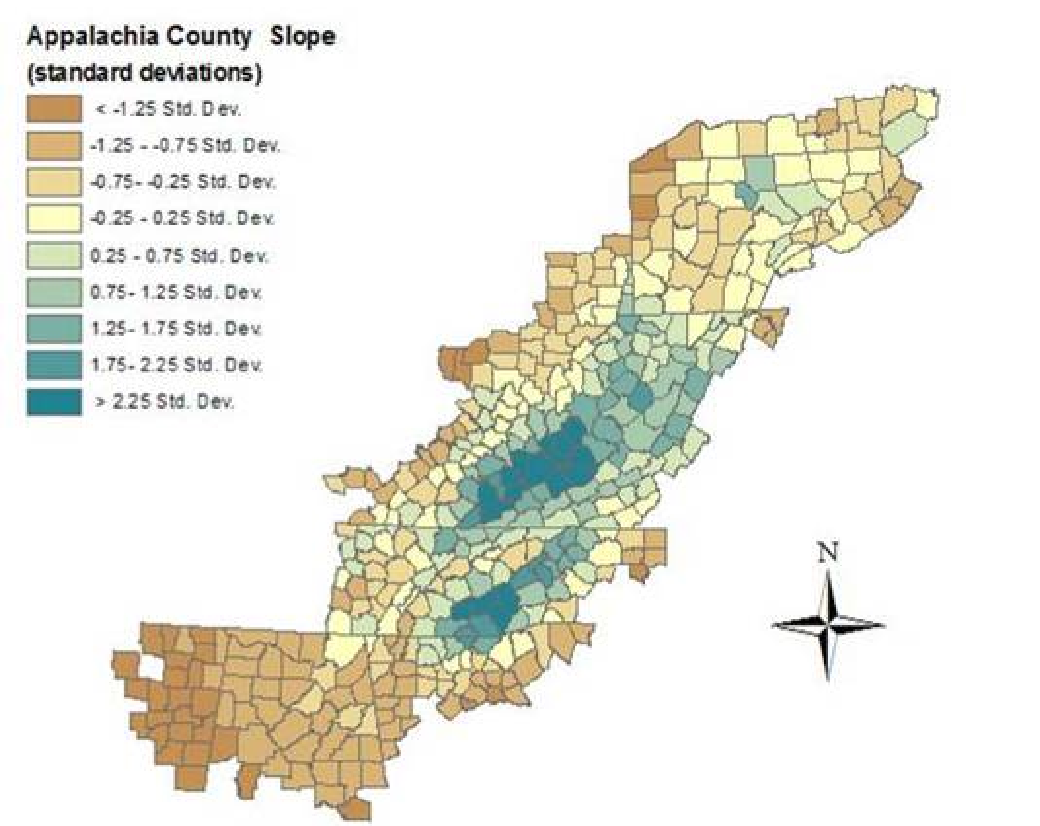
- *Transportation Infrastructure – Road Density.* Our team obtained National highway data from 2004 National Highway Planning Network (NHPN), Federal Highway Administration, U.S. Department of Transportation. We also obtained additional, more detailed, Appalachian Development Highway System (ADHS) data from the ARC. With these data, we developed estimates of road density within each county (variable name ROADWT)

- *Worker Accessibility.* Using data compiled for the Local Economic Assessment Package, we obtained a data set estimating the number of workers who live within 50 minutes driving time of each county. We use this data as a measure of each county's labor market accessibility (variable name EMP50M).

We first ran a new regression model in which we added the access measures and geography measures as cited above. Both a standard OLS regression (Model 2-A) and as a spatial error regression (Model 2-B) were run. However, the results showed that none of the access and geography measures was statistically significant in explaining county-level economic health. It was believed that the reason for this result is that the effect of access and geography is likely to differ for metro and non-core counties. Accordingly, a new variation on the model was run in which coefficients for the explanatory variables were interacted with dummy variables for metropolitan and non-metro areas. That attempt, using metro/ non-metro interaction variables, was more successful. It is referred to as Models 2-C and 2-D, and is discussed and shown next.

(Results for the earlier Models 2-A and 2-B are not shown in this summary although they are shown in the full report.)

Exhibit 5-6: Slope Estimate for the Appalachian Region (Based on USGS 90m Elevation Data from the National Map)



Source: MIT-DUSP ARC Research Team using ArcGIS.

Model 2(C-F): Interaction of Metro Status with Geography and Access. The alternative model specifications included interactions between type-of-county and the other explanatory variables. The interaction of labor market and non-metro status was added in Models 2-C (OLS model version) and 2-D (spatial error model version). The further interaction of slope factors and non-metro status was added in Models 2-E (OLS model version) and 2-F (spatial error model version). In both cases, the spatial error version provided a better fit than the OLS version, although the coefficient estimates were generally consistent across both model types. For brevity, results are shown only for the spatial error versions in Exhibit 5-7 (though results for the other model variations are shown in the full report.)

The spatial error results for Models 2-D and 2-F confirm that the effects of several variables do differ depending on whether a county's status is metro or non-metro. Results are shown in Exhibit 5-7 just for the statistically significant variables. Note that variables interacted with the metro dummy variable are denoted by an "M_" prefix and those interacted with a non-metro dummy variable are denoted by an "N_" prefix.

The results show that slope and labor force access measures do have statistically significant effects in predicting economic health level, but only in the non-metro counties (indicated by coefficients for variables N_SLOPE, N_SLOPE66, and N_EMP50). We are not surprised by the overlapping effects of employee access and terrain, because we expect that employee accessibility will be lower in mountainous areas and that non-core counties might benefit if the counties that surround them are relatively mountainous and inaccessible.

The coefficient values for the slope variables also show that above average slopes *within a non-core county* (N-SLOPE) are associated with weaker economic levels, while above average slopes *in surrounding areas* (N_SLOPE66) are associated with stronger economic levels. Those findings are plausible. In metro areas, density and infrastructure make the slope and employee access measures less relevant. Also, place-of-residence and place-of-workplace are more likely to span counties in metro areas[16].

Exhibit 5-7: Coefficient Comparison of MODEL-2 Variations

	Model 2-D *Spatial-error model with worker access and road density*			**Model 2-F** *Spatial-error with local and nearby slopes*		
Variable	**Coeff.**	**Z-Val.**	**Prob.**	**Coeff.**	**Z-Val.**	**Prob.**
CONSTANT	5.67570	35.3827	0.00000	5.66271	34.8558	0.00000
PCTHSGRAD	-0.01688	-13.9391	0.00000	-0.01702	-14.0408	0.00000
PER_MINORI	0.00324	4.5158	0.00001	0.00343	4.6660	0.00000
PCTSAMCNT_	0.00590	4.9752	0.00000	0.00594	5.0046	0.00000
DEPTHINC2	-0.00860	-3.6808	0.00023	-0.00895	-3.8275	0.00013
DEPTHVALAD	0.19684	2.2972	0.02161	0.20793	2.4263	0.01525
FAC1_2000	-0.02636	-3.6787	0.00023	-0.02727	-3.8094	0.00014
FAC2_2000	0.04371	6.1400	0.00000	0.04153	5.7560	0.00000
FAC4_2000	-0.02371	-4.3558	0.00001	-0.02379	-4.3710	0.00001
M_RADJ97	-0.00545	-5.7599	0.00000	-0.00488	-4.3712	0.00001
M_ROADWT	-0.00814	-3.7559	0.00017	-0.00626	-2.3412	0.01922
N_EMP50M	-0.00825	-2.6881	0.00719			
N_SLOPE				0.00584	2.6972	0.00699
N_SLOPE66				-0.00588	-2.1887	0.02862
LAMBDA	0.884	92.985	0.000	0.89497	104.1315	0.00000
Log-likelihod	320.9			320.2		
Akaike info	-617.8			-614.5		
R-Squared	83.3%			83.2%		

Source: MIT-DUSP ARC Research Team.

[16] An alternative explanation is that the commute-sheds do a better job of capturing high economic impact regions within metro areas since the weights matrices are not sensitive to the number of cross-county employees.

5.4 Modeling Changes in Economic Health

We have made several attempts to measure *changes* in economic status, so that we could have a stronger econometric underpinning for modeling economic growth over time and space (Anselin, 2003; Feser, 2005). We consider changes in the ELI measure during the last decade, and attempt to estimate and analyze the change in value added (per employee) as a dependent variable between 1997 and 2002 using IMPLAN data. In both cases, the results were limited with, for example, R-square values in the teens. Although we expect lower R-square values when modeling differences, a closer look at the data suggested deeper problems. The time series of annual income and poverty data underlying the ELI measure are based on sample sizes and estimation methods that vary somewhat from year to year. Large samples, such as for the decennial census, are not repeated annually. Hence, year-to-year changes tend to track simple trends. Then, when the next large data sample becomes available, big changes occur all at once in those places that have not followed the fitted curve. The measurement noise that is thereby added to the data can be significant when studying small counties or developing indices that fuse data from different sources or analysis subsectors of the economy.

The most success that we have had with modeling temporal changes in economic indicators for Appalachia has been in studying employment growth during the 1990s after controlling for labor-market conditions and other factors, such as labor mobility, natural amenities, and market size. One member of the research team, worked on this analysis for her Master of City Planning Thesis, "Industrial Structure and Employment Growth in the 1990s in Appalachian Counties."

Before presenting the *economic change* models, we will explain and summarize the measures that we use to characterize economic growth of Appalachian counties during and since the 1990s.

Changes in ELI. It is important to note that the Economic Level Index (ELI) was developed by averaging the county unemployment rate, poverty rate, and per capita market income levels (all expressed as a percentage of the US average). These components are developed from different samples taken at different points in time. When selecting two points in time for use in modeling change, we should be cognizant of the sampling and accuracy issues in the datasets. The ELI estimate for 2004 is the most recent estimate that could be computed using datasets available at the time (in 2005) that we assembled the data – and is the first 2000+ estimate that includes the results of the 2000 US Census. Analysis of the changes in ELI (variable NEW_DELI) showed that the larger improvements tended to be along the edge of Appalachia east of Cincinnati and Louisville or northwest of Atlanta.

Changes in Employment during the 1990s. Because the ELI measure is a composite index of poverty, employment, and income outcomes, it is difficult to construct an economic model of growth that can directly account for spatial and temporal impacts on ELI. As an alternative measure of changing economic conditions, we examined changes in employment in Appalachia counties during the 1990s. We used the percentage change in employment and adjusted the results (using shift-share analysis) to account for national trends in industrial sectors. The variable CMPT_CAP measures each county's percent change in employment during the 1990s above and beyond whatever change might have occurred if the county followed national trends.

These competitively adjusted changes in employment levels represent a measure of economic growth that can be regressed against demographic, industrial mix, geographic, and other factors in order to identify the conditions that resulted in faster (or slower) growth and to estimate the extent of spatial spillover effects whereby neighboring counties amplified (or, possibly, diminished) the local rate of growth[17]. Tan (2005) explains the methodology in detail.

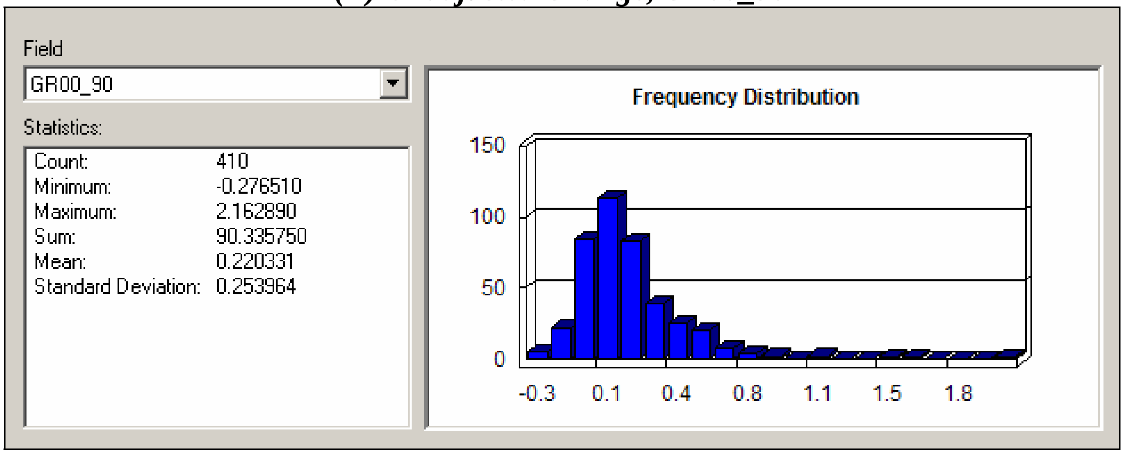
Exhibit 5-8 contains the histogram plots of 1990-2000 employment changes for ARC counties. Part A shows the unadjusted percent changes, GR00_90, and Part B shows the competitively-adjusted changes in employment levels, CMPT90_00. The 1990s were a period of economic growth for the entire nation so the 22% mean percentage increase in employment is no surprise. However, the large range and standard deviation is noteworthy. The distribution of competitively adjusted employment changes is similar in shape and standard deviation but shifted negative (with a mean of -15.9%) because Appalachia counties did not fare as well as the nation on the whole.

Exhibit 5-9 plots these changes in employment thematically across the 410 Appalachia counties. The map on the left shows the competitively adjusted employment changes whereas the map on the right shows the unadjusted employment-change results. A cluster of high-growth counties is evident in the Southeast (that is, northwest of Atlanta). Another group of low-growth counties is visible in the Eastern Kentucky and West Virginia area, but the competitive adjustment tends to temper the magnitude of these changes.

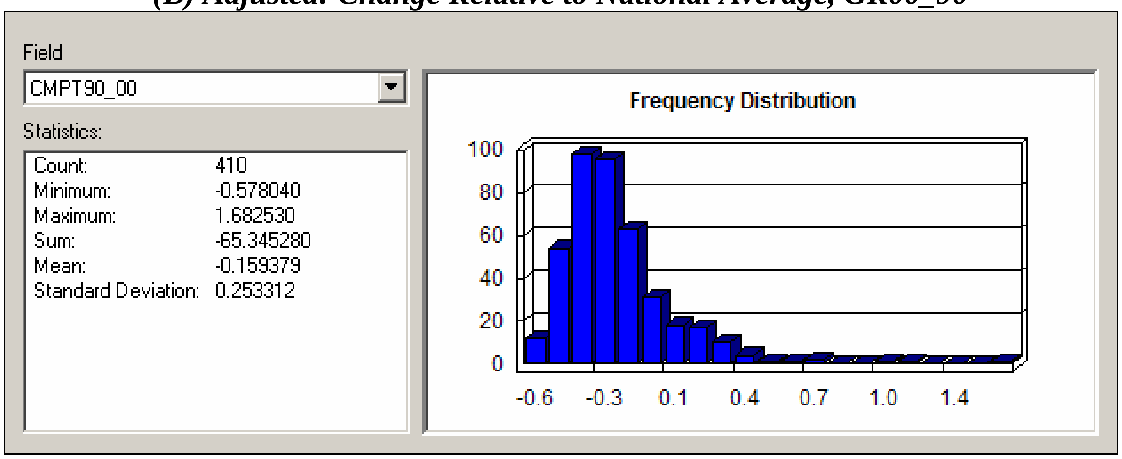
[17] Anselin (2003) has explained how weighted regression fits of such models can estimate first-order spatial-lag and spatial-error effects and Boarnet (1994), Feser and Isserman (2005), and others have developed simultaneous-equation models of employment and population size that can be used to model economic growth and estimate spatial-spillover effects.

Exhibit 5-8: Histogram of 1990-2000 Percent Change in Employment

(A) Unadjusted Change, GR00_90

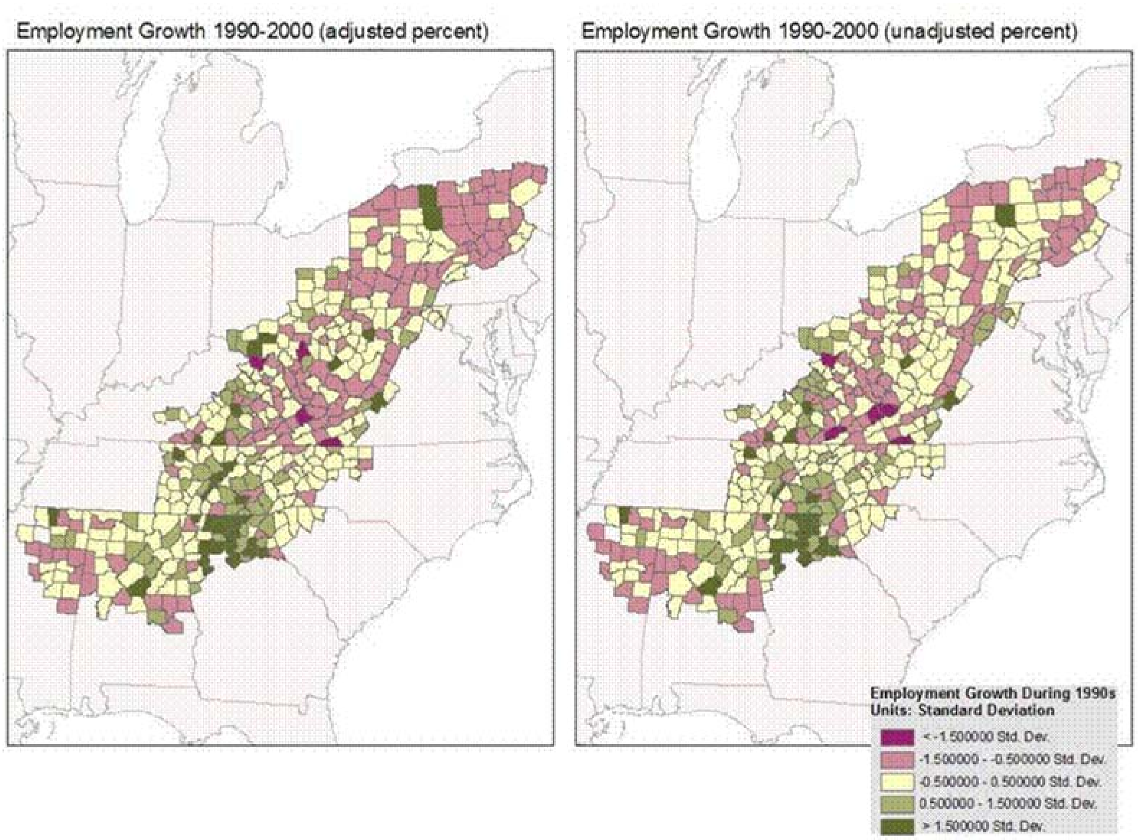


(B) Adjusted: Change Relative to National Average, GR00_90



Source: MIT-DUSP ARC Research Team.

Exhibit 5-9: Employment Change within Appalachian Counties (1990 -2000)
Source: MIT-DUSP ARC Research Team using ArcGIS.



Model 3 and Model 4-A: ELI Rating Change vs. Employment Change. We begin the discussion of *economic change* models by considering the same right-hand-side variables that we used earlier to estimate effects on recent *economic health levels* in Models 1 and 2. Some minor changes are in order, however, because we want the measures of the right-hand side variables at or near the start of the period for which change is observed – 1997 for change in Economic Level Index (NEW_DELI) or 1990 for the competitively adjusted and capped employment change (CMPT_CAP).

Initially, parallel OLS regressions were run to estimate effects on ELI change (in Model 3) and effects on employment change (in Model 4A). The results indicated a poor fit, particularly for the ELI change, where the R^2 indicated that only 16% of the variance was being explained by the model. A substantially better R^2 of 32% was achieved for the model of employment change. Actually, this difference was expected, given the coarse and discrete nature of the ELI rating changes and the smoother nature of variation in the employment change measure. Based on these findings, it was decided that better results could be obtained by focusing on the determinants of employment change, and that the spatial lag and spatial error model forms were likely to yield better fits to the data. Those results are presented and discussed next. (For brevity, results of Model 3 and 4-A are not shown here though they are presented in the full report.)

Model 4(B-C): Change in Employment. Exhibit 5-10 shows the results of models to predict employment change, using both spatial lag approach (Model 4-B includes the rhs variable **W_CMPT_CAP**) and spatial error approach (Model 4-C). Both models attempt to predict the employment change variable using the same right-hand side variables (or their early-90 equivalent) that were previously used in Model 2-A to predict current ELI levels. The results for both new models show better explanatory power (R^2 = 38%) than the previously discussed OLS results. However, the model fit for explaining *economic change* is still far lower than the explanatory power of similar regressions that explained current *economic performance levels*. That is not unexpected, since there is greater variation in the dependent variable depicting a growth rate and the explanatory variables have some updating limitations that were previously discussed.

There are some surprising findings shown in the employment change results. Educational attainment (PCTHSGRAD) is now showing a significant but counter-intuitive relationship on employment growth (this interpretation was acceptable when the dependent variable was current ELI). Adjusted employment growth outcomes in neighboring counties will exert a significant influence on a county's employment changes in the same direction. The key importance of prior industry mix also remains strong, though there are some differences. In the earlier Model 2-A of ELI *levels*, industry factors 1, 2, and, 4 were significant. For the new models of employment *changes*, factors 3 and 4 are significant. They both exert positive effects on the adjusted employment growth that occurred between 1990 and 2000.

Some of the other results are less expected. The industry concentration measure (BEAGINI_9) appears insignificant, as do the economic breadth (BREADTH) and amenity (ASCALE) variables. However, all of these unexpected results can be attributed to correlation with other variables and equally importantly, differences in their impacts within metro vs. non-metro areas.

Model 4(D-F) Metro and Non-Metro Differences. To test this last hypothesis, separate model runs were made for those counties designated by USDA as metropolitan, micropolitan, and non-core counties. The explanatory variables included the demographic variables measuring education, minority and senior citizen presence, and mobility (percent of population living in the same county for at least 5 years); the four industrial mix factors from the factor analysis plus a measure of industry concentration (BEAGINI_9); the three worker access measures counting (counting workers within 40, 50, and 60 minutes) plus the place-of-residence adjustment of worker-based-county income, RADJ97_EMP; and the various geography and infrastructure measures: ASCALE for the USDA amenity index, ROADWT for the weighted percentage of land used for major roads, SLOPE for the average slope, and AVG_SLOPE6 and AVG_SLOPE1 for the average slope of neighboring counties within 66 and 100 km. The results are shown in Exhibit 5-11, and they reveal that the impact of the same explanatory variables differed considerably across the three types of counties.

EXHIBIT 5-10 Model 4-B,C: Models of Employment Change Over Time

	Model 4-B *Spatial-lag model*			**Model 4-C** *Spatial-error model*		
Variable	**Coeff.**	**Z-Val.**	**Prob.**	**Coeff.**	**Z-Val.**	**Prob.**
W_CMPT_CAP	**0.497**	**14.405**	**0.000**			
CONSTANT	**1.213**	**5.123**	**0.000**	**1.241**	**4.460**	**0.000**
PHSGRAD90	**-0.005**	**-4.254**	**0.000**	**-0.006**	**-3.678**	**0.000**
PMINORI90	**-0.004**	**-3.872**	**0.000**	**-0.004**	**-3.218**	**0.001**
PSAMECNT90	**-0.011**	**-6.033**	**0.000**	**-0.010**	**-5.310**	**0.000**
BEAGINI_9	-0.092	-0.470	0.638	-0.036	-0.190	0.849
F1_1990	-0.023	-1.741	0.082	-0.016	-1.196	0.232
F2_1990	0.008	0.709	0.478	0.005	0.361	0.718
F3_1990	0.026	**2.238**	**0.025**	**0.031**	**2.697**	**0.007**
F4_1990	0.034	**3.307**	**0.001**	**0.030**	**3.075**	**0.002**
RADJ97_EMP	-0.002	-1.327	0.184	**-0.004**	**-2.199**	**0.028**
SLOPE	-0.002	-0.702	0.483	-0.006	-1.836	0.066
ROADWT	0.000	-0.104	0.917	-0.001	-0.150	0.881
EMP50MINK	0.002	1.857	0.063	0.001	0.984	0.325
AVG_SLOPE6	-0.001	-0.267	0.790	-0.002	-0.408	0.683
LAMBDA				**0.698**	**29.578**	**0.000**
Log-likelihod	121.0			121.1		
Akaike info	-211.9			-214.1		
R-Squared	.38			.38		

The results in Exhibit 5-11 show that the best fit was obtained for the metropolitan counties (Model 4-D), with 57 percent of the variability in employment growth explained by the model. For micropolitan counties (Model 4-E), the explanatory power dropped to 33%, and for non-core counties (Model-4-F), the explanatory power dropped to 18.5%.

Not only did the goodness of fit vary, but the selected variables and coefficients vary as well. High school graduation rates (PHSGRAD90) matter for metro and non-core counties (not for micropolitan counties) yet the sign once again is negative as seen above in results for Models 4-B and 4-C – indicating *slower* growth rates in counties with more educated populations. The minority share of the population does not matter in metropolitan counties, matters most in micropolitan counties, and matters somewhat less in non-core counties. In both cases, the sign is negative indicating that counties with higher minority shares grow at slower rates. The adult population share, PROP65_90, matters only for micropolitan counties and also has a negative coefficient. The mobility measure, PSAMECNT90, is significant for all three county types but is estimated to have less than half the impact in non-core counties. Once again, the sign is negative.

Exhibit 5-11: MODEL-4 Stepwise OLS Fits for Metro/Micro/Non-Core Submarkets

		Model 4-D Metropolitan Counties *(109 as of 1993)*				**Model 4-E** Micropolitan Counties *(118 as of 1993)*				**Model 4-F** NonCore Counties *(183 as of 1993)*			
Theme	**Variable**	**B***	**Beta***	**T**	**Sig.**	**B***	**Beta***	**T**	**Sig.**	**B***	**Beta***	**T**	**Sig.**
	Constant	1.848		7.312	0.000	1.265		2.920	0.004	1.071		4.320	0.000
Demographics	PHSGRAD90	-0.009	-0.263	-4.025	0.000					-0.007	-0.435	-5.646	0.000
"	PMINORI90					-0.007	-0.287	-3.261	0.001	-0.002	-0.158	-2.270	0.024
"	PPOP65_90					-0.020	-0.169	-2.142	0.034				
"	PSAMECNT90	-0.018	-0.536	-7.729	0.000	-0.019	-0.347	-4.234	0.000	-0.007	-0.288	-3.812	0.000
Concentration	BEAGINI_9					0.825	0.233	2.665	0.009	-0.439	-0.170	-2.196	0.029
Industry Mix	F1_1990												
"	F2_1990									0.053	0.326	4.200	0.000
"	F3_1990					0.081	0.318	3.615	0.000				
"	F4_1990	0.053	0.212	3.196	0.002	0.044	0.180	2.223	0.028				
Worker Access	EMP40MINK												
"	EMP50MINK					0.026	0.171	2.049	0.043				
"	EMP60MINK	0.003	0.267	3.692	0.000								
Residence	RADJ97_EMP												
Amenity	ASCALE												
Infrastructure	ROADWT												
Terrain	SLOPE												
"	AVG_SLOPE6												
"	AVG_SLOPE1												
	Steps**		4				7				5		
	Adjusted R^2		0.570				0.332				0.185		

** B = the coefficient estimate and Beta = the standardized coefficient estimate*
*** Stepwise ordinary least squares regression of CMPT_CAP (capped, competitively-adjusted employment percent growth 1990-2000) for 410 ARC Counties on the eighteen variables. Separate runs by 1993 USDA County type: Metropolitan, Micropolitan, Non-Core.*

Source: MIT-DUSP ARC Research Team.

The industry concentration GINI measure (BEAGINI_9) is not significant for metro counties but was significant – with different signs – for micro and non-core counties. In micropolitan counties, increased industry concentration correlates with faster growth, but in non-core counties, increased industry concentration correlates with slower growth (and the coefficient estimate was half as large). The results for the industry mix factors are also interesting. Only the fourth factor, F4_1990, matters in metro counties. This factor emphasizes construction/transportation/agriculture without government/services and higher factor scores correlates with faster growth. For micropolitan counties factor 4 still matters (a little less), but factor 3 is even stronger (and also positive). Factor 3 emphasizes government/agriculture/construction without wholesale trade. On the other hand, for non-core counties, only factor 2 matters (positively). Factor 2 emphasizes manufacturing and wholesale trade without mining and government.

The worker access measures matter most for micropolitan counties and not at all for non-core counties. The worker count within 50 minutes, EMP50MINK, performs best for micro counties, but the 60-minute count, EMP60MINK, performs best for metro counties. Note that the coefficient is much smaller for metro counties (0.003 vs. 0.026) but, based on the standardized Beta coefficient, is more influential for metro counties (0.267 vs. 0.171). The worker access distribution is skewed with a long right tail for counties close enough to large metropolitan areas. Hence, the smaller coefficient will tend to be applied to a much larger worker access count, EMP60MINK, for metro counties than for the micropolitan counties that are further from the large metro centers and where the best fitting variable is the 50-minute count, EMP50MINK.

The place-of-residence adjustment, RADJ97_EMP, was not significant for any of the three county types and neither were the amenity, infrastructure, and terrain measures. Because these models predict employment growth by place of employment, we are not surprised that the place-of-residence income adjustment is not relevant (even though it was for earlier ELI models that focused on unemployment, poverty, and income by place of residence). The amenity variable, ASCALE, focuses (as explained earlier) on the scenic and recreational features of a county and other counties might be the ones that benefit economically from these features (e.g., a county along the highway that leads to a national park located in the next county). The terrain measures could well have less effect on 10-year growth than they did for the earlier cross-sectional models. For example, there could be a long-standing advantage to counties in the valley vs. in the hills that explains the much lower density, income, etc. in the hills, even if the recent 10-year employment growth rate is similar.

Another possible explanation for the limited effects of geography in Exhibit 5-11 is that the OLS fits do not account for spatial-spillover effects. The spatial-lag and/or spatial-error models that account for spillover effects within commuting zones consistently outperform the OLS fits. From earlier runs, we see that these spatial models alter the significant variables as well as the coefficient values. Unfortunately, the models and estimation algorithms needed to handle both county stratification and spatial effects are beyond the scope of this study. For example, commuting zones often include a mix of metro, micro, and non-core counties. We cannot meaningfully run the GeoDa models separately for metro, micro, and non-core counties.[18] Nevertheless, our analyses have provided useful insights into both the factors (and county differences) that influence growth rates and the spatial relationships that influence county interactions. In this section, we summarize these findings and draw conclusions regarding decision tools that can assist in identifying promising development strategies.

5.5 Uses and Limitations of the Findings

The analyses demonstrate the importance of demographic, industry mix, and spatial interactions in explaining differences across ARC counties in their economic health and growth rates. The most interesting results relate to the explicit inclusion of detailed geography, infrastructure, and spatial dependencies in models of economic health and growth. We demonstrated that useful measures of geographic influence could be computed, using modern GIS tools, from readily available data in a manner that is practical and consistent across an area as large as Appalachia. Use of GeoDa has also demonstrated the importance of modeling spatial dependencies explicitly in order to avoid fitting miss-specified ordinary least-squares models that can overstate individual factor coefficients as a result of ignoring spatial dependencies. We have also demonstrated circumstances (the commute shed) in which the nearest-neighbor adjacency was *not* the best way to model spatial dependency.

Nevertheless, despite the progress with improved spatial-analysis tools, the model specifications do not go as far as we would like in linking policy options and development strategies to predicted outcomes. The employment growth model does, indeed, use change data to calibrate the parameters. However, we have not explicitly modeled the development process responsible for observed employment changes. We have not, for example, specified an underlying "economic-growth" model that postulates primary industries, demand for ancillary services, import and export flows, and the like, in order to identify which public investments are most likely to yield the biggest returns through exports and local multiplier effects.

Acquiring the data (e.g., freight flows) needed to calibrate such models is impractical at present, and, in the parts of Appalachia that are most in need of assistance, traditional economic-base analysis is likely only a piece of the tool-kit needed to help inform the right development questions. In the small, non-metro counties that are transitional, the size of the multiplier effect associated with project investment

[18] In order to use tools such as GeoDa to estimate spatial spillover effects for mixed models that allow differing variable coefficients by county type with clusters of 'connected' counties, we would have to transform all the variables and include county-type interaction terms that measured deviations from the main (non-interacting) effects. This is beyond the scope of the current study.

depends on many local factors that are not readily observed and estimated. How much of the new money will recycle locally may not be evident or easily modeled from standard data sources. Also, the "connectivity" mechanism that facilitates spillover and other multiplier effects may not be visible and may be relatively different from a "next-door" adjacency model. A "tourism" strategy, for example, might involve spillover effects along the transportation corridors to the tourist sites, whereas a "knowledge economy" strategy might build social networks that leapfrog counties or even states. The appropriate connectivity matrix for studying (and forecasting) spatial dependencies in these cases could look very different from either the nearest-neighbor or the commute-shed examples that we considered.

Consider, for example, that the employment growth models worked best for metropolitan counties (57% explained) and least well in non-core counties (18% explained). Upon reflection, these variations are not surprising because the traditional export-base model of economic growth is likely to work better for metropolitan areas with sizeable economies, and well developed infrastructure and commute sheds. A further analysis of the Appalachian commute sheds also showed that most include a mix of at least two county types.[19] Many of the more distressed counties are in commute sheds that include no metropolitan county.

Rather than try to identify a single, complex model for explaining growth across all county types, it may be more useful to turn the question around and ask which of several types of models is most appropriate for a county depending upon the characteristics of that county and its neighbors. If, for example, a county has favorable demographics and is in a commuter shed that includes a metropolitan area, then a traditional economic development strategy aimed at the commuter shed may be beneficial and able to capitalize on favorable spillover effects for that county. However, if the commuter shed includes only non-core counties without favorable demographics and industry mix, then traditional development strategies may not be effective, and growth in neighboring commuter sheds might even have unfavorable "backwash" effects.[20] For these counties, more promising development strategies might focus less on commuter-shed 'neighbors' and more on supply-chain possibilities or amenity-driven development. Would it make sense for the county to grow its warehouse facilities, is the county along the path from a population center to potentially attractive amenities, etc.?

Research our team conducted for the white papers and other aspects of the project suggests that, for many transitional counties, the development choice is not a matter of fine-tuning the investment strategy and choosing the one with the biggest multiplier. Instead, it is likely to involve sizing up whether one or another of a few plausible growth paths is practical, given the current circumstances for the county and its

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[19] The map also highlights the need to include non-ARC border communities in further analysis because many one- or two-county commute sheds at the edge of the Appalachia region are really part of a larger commute shed, including sheds oriented toward metropolitan centers outside ARC.

[20] A recent study by Feser and Isserman (2005) of employment and population growth in all US counties provides evidence of both favorable spillover and unfavorable backwash effects for non-metro counties.

neighbors. In order to make tourism work, a county needs access to tourists, desirable venues, highways and motels, etc. For a retirement community, or industrial park to work, a different set of questions would be asked. The most effective use of empirical analyses may be to support these evaluations with good (electronic) bookkeeping and visualization. How many people are less than two hours driving distance away from their work? Which counties will benefit from (or contribute to) a new development in a county if the county undertakes certain type of strategies? What gaps exist in the supply or demand for services, infrastructure, skilled workers, etc. What questions should a county ask in order to see if one or another growth model is plausible for the county? Is the county near a metropolitan area, along a transportation corridor, etc.? Modern web-mapping tools and online services are making it practical to acquire data and develop visualization tools and indicator systems that can greatly facilitate "what if" dialogues with citizens and local agencies. Fieldwork and case studies will help when combined with the kind of empirical analysis we have done to measure geographic constraints, neighborhoods, and opportunities. Also, analysts might use outlier counties identified by models, such as the ones we calibrated, to identify places to look for success/failure examples.

Such an approach suggests a policy-oriented decision strategy that:

(a) identifies different sets of potential partners for each county based on the growth model that might be emphasized (for example, counties in the same commuting zone for traditional export-base growth, but counties along the TVA riverway for particular supply-chain analyses, or counties along a highway corridor for certain amenities strategies),

(b) compares the characteristics of the county (and its "neighbors") with those suggested by the relevant right hand side variables for *the growth model that matches the particular development strategy being contemplated* to see whether one or more of these strategies has the factor levels needed to suggest a high likelihood of success (e.g., do not use an export-base strategy for an isolated county with poor transportation infrastructure),

(c) checks whether the type of economic development that is anticipated will be structured in a way that leaves value-added in the county (e.g., mining can benefit locals a lot or a little depending on whether most of the value-added is recirculated in the community or shifted to remote shareholders), and

(d) identifies complementary investments (e.g., in other "neighboring" counties) that would help the group of "neighbors" assemble the factors needed to tap local synergy and enhance the likelihood of success.

5.6 References

Anselin, Luc, Attila Varga, and Zoltan Acs. 1997. "Local Geographic Spillovers between University Research and High Technology Innovations." *Journal of Urban Economics*. 42: 422-448.

Anselin, Luc, Attila Varga, and Zoltan J. Acs. 2000. "Geographic and Sectoral Characteristics of Academic Knowledge Externalities." *Papers in Regional Science*. 79: 435-443.

Anselin, Luc. 2003. "Spatial Externalities, Spatial Multipliers, and Spatial Econometrics." *International Regional Science Review.* 26 (2): 153-166.

Domar, Evsey. 1946. "Capital Expansion, Rate of Growth, and Employment." *Econometrica* 14 (April): 137-147.

Feser, Edward, and Andrew Isserman. 2005. *Urban Spillovers and Rural Prosperity*, University of Illinois, Urbana-Champaign.

Goodchild, Michael 1986. *Spatial Autocorrelation*, CATMOG 47, Norwich, UK: Geo Books.

Henry, Mark S., David L. Barkley, and Shuming Bao. 1997. "The Hinterland's Stake in Metropolitan Growth: Evident from Selected Southern Regions." *Journal of Regional Science,* 37(3): 479-501.

Isserman, Andrew M., and John D. Merrifield. 1987. "Quasi-Experimental Control Group Methods for Regional Analysis: An Application to an Energy Boomtown and Growth-Pole Theory." *Economic Geography*, 63 (1): 3-19.

Jaffe, Adam 1989. "The Real Effects of Academic Research," *American Economic Review,* 79(957-70).

Karkalakos, Sotiris. 2004. "The Spatial Boundaries of Regional Technological Productivity in European Union." Working paper.

Leichenko, Robin. 2000. "Exports, Employment, and Production: A Causal Assessment of US States and Regions**."** *Economic Geography,* 76 (4): 303-326.

Martin, Ron, and Peter Sunley. 1998. "Slow Convergence? The New Endogenous Growth Theory and Regional Development." *Economic Geography*, 74(3): 201-227.

Ramajo, Julián, Miguel Márquez, and María del Mar Salinas. 2004. "Spatial Patterns in EU Regional Growth: New Evidence about the Role of Location on Convergence." (*mimeo, en evaluación)*

Sala-i-Martin, Xavier. 1996. "Regional Cohesion: Evidence and Theories of Regional Growth and Convergence," *European Economic Review*. 40: 1325-1352..

Schaffer, William A. 1998. *A Survey of Regional Economic Models*. Atlanta, GA: Georgia Institute of Technology. http://www.rri.wvu.edu/WebBook/Schaffer/chap02.html

Smirnov, Oleg, and Alena Smirnova. 2000. "An Assessment of the Economic Base of Distressed and Near-Distressed Counties in Appalachia." Report to the Appalachian Regional Commission, report from Bruton Center for Development Studies, School of Social Sciences, The University of Texas at Dallas.

Solow, Robert. 1956. "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Development Economics* 70(1): 65-94.

Stirboeck, Claudia. 2004. "A Spatial Econometric Analysis of Regional Specialisation Patterns across EU Regions." ZEW Discussion Paper No. 04-44. http://ssrn.com/abstract=560884

Tan, Zhijun, 2005. "Industrial Structure and Employment Growth in the 1990s in Appalachian Counties," MIT MCP Thesis (August) Cambridge, MA: Department of Urban Studies and Planning, Massachusetts Institute of Technology.

Vias, Alexander C., and Gordon F. Milligan. 1999. "Integrating Economic Base Theory with Regional Adjustment Models: The Nonmetropolitan Rocky Mountain West." *Growth and Change*, Vol. 30 (Fall): 507-525.

Widner, Ralph R. 1990. "Appalachian Development After 25 Years: An Assessment." *Economic Development Quarterly*, 4(4): 291-312.