Final Report

On

Transportation Infrastructure and Rural Economic Growth

By

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Abstract. This study examined how various inputs including employment agglomeration in different industries affected economic growth of the Arkansas State. Potential regional output, defined as a gross county product, was evaluated using Cobb-Douglas production function and compared with an actual output. Substitutability of considered inputs was defined. Inputs constraining local growth were determined by categorizing them as bottlenecks or excess capacities. Analysis showed locations that were able to successfully substitute infrastructure, human capital, and amenities were more likely to see increased gross county product.

Keywords: transportation infrastructure, employment agglomeration, input potentials, input utilization, personal income.

Transportation Infrastructure and Rural Economic Growth

Introduction

In a predominantly rural state like Arkansas each community has to decide its fate as whether to inhibit or promote economic development. Most suburban and rural communities will attempt to attract growth. However, some communities may see economic development as a threat to the quality of life. Suppose community decided to choose economic development as its strategy. What factors can contribute to the success of this particular community in its efforts to promote this development? Can some factors of production substitute for the lack of others in this process?

Economic growth can be attracted through some economic activity. That is why authors of this study were trying to examine how employment agglomeration in different industries and the usage of other inputs affected economic development in the Arkansas State. There are several types of agglomeration exist: agglomeration economies resulting from the concentration of the same or similar activities (localization economies) and agglomeration of population and urbanization of an area or other economic activities benefiting from the access to a general labor force (urbanization economies).

Localization economies allow firms benefit in cost savings through concentration of similar economic activities (clustering) and knowledge spillovers (Malmberg and Maskell, 2001). The concentration of activity in a particular area should lead to a larger labor pool with the appropriate skills for the industry or associated industries related to the concentrated activity. Agglomeration economies are especially important in manufacturing sector since most manufacturing establishments are dependent on agglomeration economies early in their development due to a substantial research and marketing costs. Mano and Otsuka (2000) in their study of manufacturing sector in postwar Japan found that congestion and competition with the service sector associated with urbanization were the major sources that reversed prior concentration of manufacturing industries in urban areas. Black and Henderson (1998) stated that many standardized manufacturing activities like textiles, food processing, steel, auto production and wood products found disproportionately located in small metro areas of the United States. These findings suggest that rural areas have some potential for attracting manufacturing or other industries and, thus, for future development.

Industrial agents searching for new plant locations are more likely to be attracted to counties in labor markets with a concentration of similar industrial activity. Researchers have indicated that concentration of economic activity or "clusters" are a leading cause of local economic growth (O'hUallachain and Satterthwaite, 1992; Henry and Drabenstott, 1996; Malmberg and Maskell, 2001). However, many rural communities lack what most economists would call a functioning cluster (a concentration of economic activity with the sharing of ideas and partnering for product development). As a consequence, firms will need to identify other means to moderate their comparative disadvantage in this area.

This research was sparked by the interest to examine how counties were developing when confronted with limited agglomeration economies. Socio-political and amenity factors were studied for their contribution to this development.

Literature Review

Previous studies on the economic development of the United States emphasized infrastructure, business climate, taxation, cost and availability of raw materials, labor, capital, access to markets, and climate when explaining growth of the region.

Plaut and Pluta (1983) in their state level analysis of industrial growth used labor and energy cost, availability and productivity variables, land and raw materials, environment, business climate, taxes and government expenditures as explanatory variables. They found market accessibility, labor variables, land, environment, business climate, and property taxes to be highly significant in explaining all three measures of industrial growth: production, employment and capital stock growth.

Carlino and Mills (1987) looked at the determinants of county growth. County level data were used to analyze what variables had an impact on the growth of population and employment during the 1970s and 1980s. Structural equations were estimated using a two-stage least-squares technique for total employment and population, and for manufacturing employment and population, since the manufacturing sector appeared to influence regional economic growth. Eight regional dummies were used to identify the association of a county to a particular region. Population density, interstate-highway density, and family income were shown to contribute significantly to the employment density growth, whereas employment, interstate-highway density, family income, and the central city dummy contributed to the population density growth.

Deller, Tsai, Marcouiller and English (2001) looked at how amenities influence rural economic growth. Economic growth was represented in their study by three types of growth: growth in population, growth in employment, and growth in per capita income. Results of their analysis showed that higher levels of income inequality are associated with lower levels of growth in terms of population. Property taxes had a negative effect on population and income growth; population over age sixty-five was negatively related with economic growth; climate strongly influenced growth levels of population; all amenity attributes, such as levels of water amenities, developed recreational infrastructure; winter recreational activities, were statistically significant and positively related to economic growth.

Government policies can have an impact on the firm's decision-making process, particularly taxation and incentive policies. Corporate income and property tax rates can affect a firm's profits either directly or indirectly (Gerking and Morgan, 1991). It is obvious that a firm's profits will decrease if the burden of an increase in taxes is borne directly by the firm. This study proved that a firm's profits decrease if the increase in taxes is passed forward to the consumer. By passing the tax to the consumer through higher prices, the firm's market will decline, thus indirectly reducing profit.

On the other hand, Newman and Sullivan argue that business taxes should not be viewed strictly as another cost to the firm (Newman and Sullivan, 1988). They perceive business taxes in part as benefit taxes. "Firms derive some benefit from local or state expenditures for fire, public safety, transportation, and perhaps education" (Newman and Sullivan, 1988, p. 216). The relevant question for the firm now would not be which location would minimize the tax burden to the firm, but what location would provide the firm with the most desirable overall fiscal package.

Agglomeration economies represent the cost savings that accrue to firms that locate in communities with a relatively large concentration of manufacturing/commercial business activity (Henry and Drabenstott, 1996; Johnson, 2001; McNamara, Kriesel, and Rainey, 1995). The concentration of activity tends to provide broader access to markets, business services, and technological expertise. In addition, agglomeration forces are generally associated with an abundant supply of skilled labor. Thus, communities in or near large Metropolitan Statistical Areas (MSAs) have location advantages over smaller and more remote communities.

Given previous research findings, variables on infrastructure, amenity variables, and property taxes were found to be significant in explanation of the economic growth. We employed these variables in our analyses and added few more variables, including agglomeration in several industries and distance to the nearest metropolitan statistical area.

This study examined how rural and small metro locations were expanding with existence of limited agglomeration economies. In particular, the study examined to what extent other factors can be substituted for manufacturing agglomeration to ensure growth of local gross regional product.

Model and the Concept of Input Potentials

The objectives of the study were to determine the relative importance of various factors in enabling a community to reach its potential output level. In addition, we analyzed whether the inputs can be substituted for one another in the production process. The study first examined output potential relative to actual output. Then the intensity of input use was analyzed to determine which factors constrained local economic growth and if other factors were compensated for the constraining factor.

Measuring potential outputs is necessary to evaluate the allocation of scarce resources, because certain regions may have an abundance of certain inputs but be deficient in others. Thus, allocating additional resources to areas that currently have abundance will not enable them to expand their economy. Conversely, withholding resources from areas that are deficient may cause them to stagnate or decline.

Potential output is defined as the theoretical output which can be attained by maximum use of all available inputs (Blum, 1982). Potential output is obtained by estimating the relationship between current input use and output levels for the areas in the study[1]. Once the relationship between inputs and output is obtained, potential output is estimated by assuming all available inputs in each location are used to maximize regional output.

In analyzing potential output, inputs are classified as being either mobile or immobile. Immobile inputs are inputs that are readily available in the local area but are not easily transported to other areas for production. Major reasons for inputs immobility include: high costs, and/or physical and geographical constraints. Mobile inputs may or may not be native to the area, but can be transported easily to and from other locations for production purposes.

Once the capacity of the immobile local input is fully utilized, further growth can only be achieved with increasing marginal costs if some immobile input can be substituted for one another in the production process. If substitution is not possible, further growth is not possible.

These analyses will allow planners and policy makers to obtain insight as to which factors may be hindering growth. Furthermore, local and state leaders can know if other local inputs can be substituted for these limiting factors. Increasing the availability of substitute inputs may allow economic growth to continue.

Regional output for our production system was defined as gross county product (GCP). GCP is the value added in production from the labor and capital located in the county. Knowing historical levels of actual GCP and local inputs levels, it is possible to estimate maximum attainable GCP. Growth potential for each region can be determined by comparing actual GCP with maximum attainable GCP on a regional level.

Given recent research finding that agglomeration leads to Increasing Returns to Scale (IRS), the functional form used in estimating the benefits of agglomeration should allow for the possibility of IRS production (Henderson, 1974). The Cobb-Douglas production function is a flexible function, which permits increasing, decreasing, or constant returns to scale. Increasing returns to scale are present when the sum of all estimated coefficients in the production function is greater than 1[2].

Following is the model used to estimate the relationship between input use and output levels in the present study:

$$\ln P(\hat{o}_{it}) = \ln a_{0t} + \sum_{j=1}^{13} a \ln \hat{o}_{it} + w = b_0 + \sum_{j=1}^{13} b_{it} c_{it} + u \ ,$$

where:

P – gross county product;

o_{it} – i-th independent variable for the t-th year;

c_{it} – natural log of the i-th independent variable for the t-th year;

a and $ß_{it}$ – parameters to be estimated in the model;

β_0 – natural log of intercept for the t-th year; and

? and ? – are the error terms.

In order to identify which inputs may be constraining local growth, we first had to identify which inputs act as substitutes for one another. If two inputs x and k are substitutes, you can maintain the same level of output by increasing the use of *x (k)* as the use of *k (x)* diminishes (i.e. sugar and high fructose corn syrup used as sweeteners). However, if *x* and *k* are non-substitutes, then you will not be able to maintain output levels by increasing *x (k)* as the use of *k (x)* decreases (i.e. lumber and nails when building a fence). Substitutability can be determined by comparing the signs of two $ß_{it}$ coefficients from the above production function. Two inputs are substitutes when the sign of $ß_{it}$ equals the sign of $ß_{jt}$ for *i* ? *j*. When all substitute inputs were determined, the average marginal rate of substitution ($\overline{MRS}$) for all regions in the study was estimated for each combination of substitute inputs (formula is given in Appendix).

Bottlenecks (input that is limiting output growth) or excess capacities (input for which the availability exceeds demand in the local economy) in the utilization of each input for an individual region can be determined by comparing the areas MRS to $\overline{MRS}$.

If $MRS_{jkit} > \overline{MRS}$, then a bottleneck exists. In this case, community *i* would need to use more of input *j* to compensate for a decrease in the use of input *k* relative to the average for the study. Assuming the price for the inputs are the same across areas and that similar technologies are being used, the relatively higher use of *j* implies the marginal cost of *k* is greater because more *j* has to be used. Additional quantities of input *k* would allow the use of input *j* to fall back in line with the average for the study and would allow output cost to decline. However, if *k* can not be increased easily, then the use of *j* allows the region to grow beyond what it would otherwise be able to given the limited amount of *k* available. In this case, input *j* is being substituted for input *k*.

Data

Panel data were collected for 75 counties from the state of Arkansas for the years 1986 through 1999. Real gross state product was used as an indicator of the economic growth. Gross state product was allocated to each county based on that county's share of state adjusted earnings. Adjusted earnings were used to account for commuting and other income transfers across county borders.

The following independent variables were collected for the study:

a) agglomeration of employment in agriculture, construction, manufacturing, wholesale and retail trade, and service industries;
b) all roads in miles;

c) number of person-trips traveled;

d) percent of population over 25 years of age with high school diploma;

e) amenity score obtained from the Economic Research Service's amenity index;

f) distance to the nearest metropolitan statistical area (MSA);

g) real per capita personal and real property tax amounts owed to school districts.

Property tax amounts were estimated using assessed values of property and millage rates for each individual county for the period studied. Calculated amounts of property taxes owed operate as a proxy for local service provisions.[3] Personal and real property tax amounts, as well as gross state and county products, were deflated using 1999 as a base year.

Data on employment agglomeration for different industries were found using the REIS web site; other data were taken from Arkansas Annual Statistical Abstracts; and data for missing years were obtained from Arkansas Departments of Transportation and Education.

Data statistics are given in Table 1.

Table 1 about here.

Results

A Cobb-Douglas production function was estimated using the SAS statistical package. Results are summarized in Table 2. Manufacturing, wholesale, and service employment agglomerations were found to be significant and contributed to the increase of GSP. The contribution from service agglomeration was the biggest, followed by wholesale agglomeration and manufacturing agglomeration. Most previous studies have tended to indicate manufacturing as being the primary stimulus of economic activity; this is due to the higher wages available in manufacturing sectors relative to service and trade sectors. However, as manufacturing has declined in importance as a source of employment, other sectors are becoming more significant. Deller et al. underlined this fact by saying that for the last two decades agriculture and manufacturing are giving way to service (Deller et al., 2001).

Table 2 about here.

As expected, agricultural agglomeration was highly significant and negatively related to the gross county product since agriculture represents an industry that offers an alternative way of land use (Blum, 1982). Wages in agriculture also tend to be lower than in other sectors. Employment agglomeration in construction and retail industries were insignificant.

The concentration of roads, measured as the number of miles in all roads divided by land area, represented infrastructure in this study. This variable was highly significant and positively related to the gross county product.

The number of person-trips per year variable represented the ability of the county to attract outside residents for business and/or personal activities in the area. This variable was chosen for its relation to the business and personal travel and service usage. The number of person-trips was highly significant and positively related to the gross county product. The amenity index showed that rural amenities contributed to the increase in income growth in the county.

Another outcome of this research is that economic development was significantly and positively related to the level of human capital in the area. The coefficient for the percent of the population with high school diploma was the highest among all variables, followed by the coefficient on infrastructure. These results imply that counties seeking to increase income growth should insure that they have a comparative advantage or at least be comparable with competing communities regarding the level of human capital and infrastructure.

Because we chose the county as a unit of economic analysis, correction for spatial autocorrelation was accounted for by introducing the variable: distance from county center to the central place of metropolitan statistical area (MSA). The distance to the center of MSA was highly significant and inversely related to the county's gross product. MSAs are the centers of economic activity, although good infrastructure can partially substitute for being further from the MSA center.

Since property taxes are an important source of the revenues for local government, per capita personal and real property taxes owed to school districts were used in this analysis. The coefficients for both variables were found to be statistically significant. Per capita personal property taxes owed to a school district contributed to the increase of the gross county product, whereas per capita real property taxes owed to a school district decreased the gross county product. Property tax revenue is primarily spent for local primary and secondary schools and community colleges (Miller, 2001). The rest of the property tax revenue goes for general county operations, roads, libraries, hospitals, and pensions. A strong positive relationship between personal property taxes and gross county product can be explained by the fact that greater revenue lead to more and/or better services improving the quality of life and productivity of private capital in the area. The fact that per capita real property taxes slowed economic growth can be explained by the housing market effect (Ihlanfeldt, 1999). Business growth increases the earnings of existing residents, brings in-migration, and increases housing demand, which in turn leads to the rise in rents and housing prices. Residents that owe property will increase their wealth and pay higher taxes. However, first time homebuyers might be shut out of the owner-occupied housing market. In turn, this may impede economic growth of an area.

Theoretical County Incomes in Factor Production

The actual Cobb-Douglass production function can be written as follows, using estimated coefficients:

$$y_{it} = 12.7731 ? \hat{o}_{1it}^{-0.1015} ? \hat{o}_{2\,it}^{-0.0265} ? \hat{o}_{3\,it}^{0.0326} ? \hat{o}_{4\,it}^{0.0537} ? \hat{o}_{5\,it}^{0.0433} ? \hat{o}_{6\,it}^{0.1727} ? \hat{o}_{7\,it}^{0.4766} ? \hat{o}_{8it}^{0.0629} ? \hat{o}_{9\,it}^{0.5855} ? \hat{o}_{10\,it}^{0.0579} ? \hat{o}_{11\,it}^{-0.0268} ? \hat{o}_{12\,it}^{0.0546} ? \hat{o}_{13\,it}^{-0.1498}$$

where:

i – 1,2,3,…,75;

t – 1986, 1987, 1988, …, 1999;

y_{it} – is the theoretical gross county product if total capacity of input potentials were used for production in region i under the assumption of efficient price systems;

$\hat{o}_{it}$ – independent variables used in estimation of gross county product.

The comparison of actual and theoretical gross county products for selected counties in Arkansas is given in Table 3. This table shows how some counties over-utilized and others under-utilized resources that were considered in this research. If the difference between theoretical and actual county products is negative and/or the ratio of actual product over theoretical product is greater than 1, then considered inputs were over-utilized.

Table 3 about here.

Regression analysis has shown that manufacturing agglomerations significantly influenced gross product. Further analysis investigates how other inputs were utilized in relation to manufacturing agglomeration. Utilization of inputs against manufacturing employment agglomeration is shown in Table 4. The following inputs were substitutional against manufacturing employment agglomeration: retail, wholesale, and service employment agglomerations, transportation infrastructure (roads variable), amenity variables (number of person-trips and amenity index), human capital variable, and personal property taxes.

Table 4 about here.

If Table 3 gives comparison of theoretical and actual county products in our study, Table 4 demonstrates which inputs were used efficiently and which were not when comparing against manufacturing agglomeration for the same selected counties. For example, Baxter County had an actual income higher than the theoretical income, thus implying that Baxter County over-utilized some of its resources. Which resources were over-utilized can be determined from Table 4. Baxter County over-utilized its retail and service agglomerations, amenities, and personal property tax when compared against manufacturing agglomeration. This implies these inputs have substituted for manufacturing agglomeration to allow regional output to expand beyond what would be capable with the current level of manufacturing agglomeration. Expansion of these factors, or, alternatively, expansion of manufacturing agglomeration, would allow the region to obtain greater growth in regional output.

However, the only factor that is under state and/or local control is the level of property taxes collected, which also served as a proxy for the amount of services that can be provided. Obtaining additional tax revenue, and thus services, would allow the region to expand its output even further. However, it should be noted that the real property tax collections lead to decline in regional output. Therefore, the community should be careful that its tax policy does not drive away industrial activity, which is more likely to pay a larger proportion of the real property taxes.

Another example is Bradley County. This county had an actual income lower than the theoretical income. According to the resource utilization in Table 4, it can be seen that this county had excess capacity in retail and service agglomeration, human capital, amenities usage, roads, and personal property tax variables substitutable for manufacturing agglomeration. The fact that the region was below its theoretical output yet had excess capacity in its inputs suggests that the region was not utilizing its resources effectively.

In the state of Arkansas, 43 counties over-utilized and 32 counties under-utilized inputs considered in this study[4]. Analysis of theoretical and actual gross county incomes in the state has shown that 90 percent of the counties that over-utilized its resources are the counties constituting MSA or counties directly adjacent to a MSA.

Table 5 provides ratios of the individual county MRS to the state's average MRS. This table shows to what extent a county utilized its resources while substituting for manufacturing. For example, the actual county product in Ashley County was lower than the theoretical county product (Table 3). Retail, wholesale, and service agglomerations, human capital, roads, amenities and personal property tax owed were not fully utilized when comparing against manufacturing agglomeration. Table 5 shows how much lower utilization of these inputs was in Ashley County in comparison to the state average. Ashley County utilized retail and service agglomerations by 78 % each when comparing to the state average, wholesale agglomeration by 53%, roads by 86%, person-trips by 82%, amenities by 74%, education variable by 86%, and personal property tax by 99% against state average. Ashley County also used its current resources inefficiently. Thus, the state should not invest additional resources into the county until steps have been taken to obtain a better return from resources currently available in the county.

Table 5 about here.

Conclusion

This study found that infrastructure (all roads), amenities (number of person-trips and amenity index score), human capital, and personal taxes contributed positively to the growth of the gross county product along with manufacturing, wholesale and service agglomerations.

Usage of each individual resource was examined for each county. The possibility of substitution of local resources for limited agglomeration economies was investigated. The results indicate that communities can potentially increase their gross county products by substituting human capital, infrastructure, and localization agglomeration for a lack of concentration in local manufacturing activity. The ability of communities to make improvements in these other substitutable areas to a large extent will determine how well economic growth will occur in the future.

The finding that most of the counties that over-utilized their inputs are either in or adjacent to MSAs implies that the benefits of locating nearer larger markets may be a stronger benefit than a manufacturing agglomeration. The importance of access to larger markets was also supported by the negative relationship found between the distance to a MSA and regional output. This suggests that greater resources are needed in rural/isolated regions to obtain the same level of growth as in metropolitan regions. A critical resource would be transportation infrastructure as it provides greater access to the larger urban markets.

This study determined factors substitutable for manufacturing agglomeration. The same needs to be done to find inputs substitutable for agglomeration in service, textile, and other industries. Thus, to overcome limitations in agglomeration economies, county government should determine the recipe or target mixes of inputs substitutable for lack of agglomeration in a certain industry.

Footnotes

[1] Regression analysis is used to estimate the relationship between observed input use and observed output levels. The estimated model is known as the production function in the economics literature.

[2] For the model estimated below, this is equivalent to ? $_{i=1}$ß$_{it}$ > 1

[3] Ideally we would have included revenue amounts but that data were not available for the entire time period.

[4] Contact the authors for the complete table for tables 3, 4, and 5.

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Table 1

Summary statistics of the data used in the study of the role of quality of life in Arkansas economic development for the period 1986-1999

Variable	Mean	Std. Dev.	Min	Max
Real gross county product	729,735,598	1,015,379,797	119,764,774	8,906,048,705
Agglomeration of employment in agriculture	11.92	6.91	0.74	37.16
Agglomeration of employment in construction	5.33	2.15	1.35	29.73
Agglomeration of employment in manufacturing	21.78	9.08	3.65	67.57
Agglomeration of employment in wholesale industry	2.95	2.01	0.11	16.42
Agglomeration of employment in retail industry	14.71	3.57	3.14	27.91
Agglomeration of employment in service	19.28	4.79	5.39	34.46
All roads in miles	1146.53	456.99	624.30	8316.00
Total number of person-trips	227,577.80	468,695.90	4000.00	4,098,817.00
Population over 25 with high school diploma	46.97	13.74	18.1	86.40
Amenity score	3.45	0.68	2	5
Distance to MSA	43.95	23.43	0.00	115.87
Real per capita personal property tax owed to school districts	69.61	38.25	25.78	410.92
Real per capita real property tax owed to school districts	173.21	45.24	97.06	352.98

Table 2

Coefficients of the Cobb-Douglass production function estimating effects of the employment agglomeration, education, amenity variables and tax rates on the county growth for the years 1986-1999

Variables	Coefficients
Intercept	12.7731*** (54.22)
Agricultural employment agglomeration	-0.1015*** (-7.47)
Construction employment agglomeration	-0.0265 (-1.70)
Manufacturing employment agglomeration	0.0326** (1.94)
Wholesale employment agglomeration	0.0537*** (5.03)
Retail employment agglomeration	0.0433 (1.54)
Service employment agglomeration	0.1727*** (4.64)
All roads in miles	0.4766*** (18.05)
Total number of person-trips	0.0629*** (8.53)
Percent of population 25 years of age with high school diploma	0.5855*** (33.20)
Amenity index	0.0579* (1.88)
Distance to MSA	-0.0268*** (-11.97)
Personal property tax owed	0.0546** (3.17)
Real property tax owed	-0.1498*** (-5.37)
F-value	1798.33***
R^2	95.71

Note. * indicates significance at the 10% level,
** indicates significance at the 5% level,
*** indicates significance at less than 1% level, t-values are given in parenthesis.

Table 3

Actual and theoretical averages of incomes of all counties of the state of Arkansas for the period 1986-1999

County name	Theoretical Income	Actual Income	Difference	Ratio
Arkansas County	480174788	402904334	77270454	0.84
Ashley County	511727369	463800288	47927081	0.91
Baxter County	595262470	628096436	-32833966	1.06
Benton County	2017225965	2064006403	-46780438	1.02
Boone County	573869995	560602112	13267883	0.98
Bradley County	260130041	222112150	38017891	0.85
Calhoun County	111111371	109586838	1524533	0.99
Carroll County	382782580	380059231	2723349	0.99
Chicot County	281956885	296809904	-14853019	1.05
Clark County	434853364	411755598	23097766	0.95
Clay County	299405467	337471733	-38066266	1.13
Cleburne County	375327078	389904673	-14577595	1.04
Cleveland County	147164968	151893690	-4728722	1.03
Columbia County	486013195	482934048	3079146	0.99
Conway County	352571688	366891246	-14319558	1.04
Craighead County	1385104624	1343893253	41211371	0.97
Crawford County	806239221	851186560	-44947339	1.06
Crittenden County	1001924694	937741260	64183434	0.94
Cross County	350209883	364750148	-14540265	1.04
Dallas County	255508637	179514465	75994172	0.70
Desha County	349248080	306500786	42747294	0.88
Drew County	327958943	330214496	-2255553	1.01
Faulkner County	1205651008	1235533501	-29882493	1.02
Franklin County	292509732	294483044	-1973312	1.01
Fulton County	203978363	194911843	9066519	0.96
Garland County	1391054784	1460618772	-69563988	1.05
Grant County	345646585	274814951	70831634	0.80
Greene County	541088774	628367705	-87278932	1.16
Hempstead County	410538925	414010852	-3471927	1.01
Hot Spring County	503988502	514766916	-10778414	1.02
Howard County	283265411	258003110	25262302	0.91
Independence Co.	569579131	603345304	-33766173	1.06
Izard County	195093380	225799128	-30705748	1.16
Jackson County	337764620	352675154	-14910534	1.04
Jefferson County	1800417406	1593012706	207404700	0.88
Johnson County	331214497	366536328	-35321832	1.11
Lafayette County	163071172	177728600	-14657428	1.09
Lawrence County	319450833	330221785	-10770952	1.03

Lee County	223199110	247677070	-24477960	1.11
Lincoln County	177729983	260933147	-83203164	1.47
Little River County	274955324	256055500	18899825	0.93
Logan County	323107450	392689964	-69582513	1.22
Lonoke County	813884375	807172186	6712189	0.99
Madison County	220331033	233466643	-13135610	1.06
Marion County	243952789	245661806	-1709018	1.01
Miller County	841794258	735919317	105874941	0.87
Mississippi County	910747266	1015607497	-104860231	1.12
Monroe County	237330686	206924955	30405731	0.87
Montgomery Co.	177023195	153349762	23673433	0.87
Nevada County	222258997	191938890	30320107	0.86
Newton County	163447435	149117841	14329594	0.91
Ouachita County	616775756	557499983	59275773	0.90
Perry County	188676310	161188980	27487330	0.85
Phillips County	502480864	537996533	-35515669	1.07
Pike County	207516670	192279002	15237668	0.93
Poinsett County	435753847	465672050	-29918202	1.07
Polk County	358180864	342185910	15994954	0.96
Pope County	1002826957	906604772	96222184	0.90
Prairie County	161726441	177709163	-15982721	1.10
Pulaski County	5857084735	6620039480	-762954745	1.13
Randolph County	286489108	321099945	-34610837	1.12
St. Francis County	489294981	539303778	-50008797	1.10
Saline County	1159138488	1288430162	-129291674	1.11
Scott County	170663305	196868135	-26204830	1.15
Searcy County	164246171	148081317	16164854	0.90
Sebastian County	1929955189	1931618432	-1663242	1.00
Sevier County	256814993	267078337	-10263344	1.04
Sharp County	357250455	289093851	68156605	0.81
Stone County	199299514	193808880	5490634	0.97
Union County	820929358	875143288	-54213929	1.07
Van Buren County	280365775	275305333	5060442	0.98
Washington County	2203285377	2354935606	-151650229	1.07
White County	962883744	1092862754	-129979009	1.13
Woodruff County	163058910	176595177	-13536267	1.08
Yell County	342405950	344643385	-2237435	1.01

Table 4
Bottlenecks (-) and Excess Capacity (+) of an Input Potentials Against Manufacturing Agglomeration for 75 counties of Arkansas State for the Years 1986-1999

MRS against manufacturing agglomeration	PC PPTO	Whole Sale	Retail	Serv.	All roads	Person -trips	High School dipl.	Amen. score
Arkansas County	-	-	+	+	-	+	+	+
Ashley County	+	+	+	+	+	+	+	+
Baxter County	-	+	-	-	+	-	+	-
Benton County	-	+	-	+	-	-	-	-
Boone County	-	-	-	-	-	-	-	-
Bradley County	+	-	+	+	+	+	+	+
Calhoun County	+	+	+	+	+	+	+	+
Carroll County	+	+	+	+	+	-	+	-
Chicot County	+	-	+	+	+	+	+	+
Clark County	-	+	-	-	+	-	+	-
Clay County	+	-	+	+	+	+	+	+
Cleburne County	+	-	-	-	-	-	+	-
Cleveland County	+	-	+	-	-	+	+	+
Columbia County	-	+	+	+	+	+	+	+
Conway County	-	-	-	-	+	+	+	+
Craighead County	-	-	-	-	-	-	-	+
Crawford County	+	-	-	+	+	-	-	-
Crittenden County	-	-	-	-	-	-	-	-
Cross County	+	-	-	+	+	+	-	+
Dallas County	+	+	+	+	+	+	+	+
Desha County	-	-	-	+	+	+	-	+
Drew County	+	+	+	+	+	+	+	+
Faulkner County	-	+	-	-	-	-	-	+
Franklin County	-	+	-	-	-	+	-	-
Fulton County	-	+	-	-	-	-	-	-
Garland County	-	-	-	-	-	-	-	-
Grant County	+	+	+	+	+	+	+	+
Greene County	+	-	+	+	+	+	+	+
Hempstead County	+	+	+	+	+	+	+	+
Hot Spring County	+	+	+	+	+	+	-	-
Howard County	+	+	+	+	+	+	+	+
Independence Co.	+	-	+	+	+	+	+	-
Izard County	-	+	-	-	-	-	+	-
Jackson County	-	-	-	-	-	+	-	+
Jefferson County	-	-	-	-	-	-	-	+
Johnson County	+	+	+	+	+	+	+	-
Lafayette County	+	+	+	-	+	+	+	+

Lawrence County	+	-	+	+	+	+	+	+
Lee County	-	-	-	-	-	-	-	-
Lincoln County	-	+	+	+	-	+	+	+
Little River County	-	+	+	+	+	+	+	+
Logan County	+	+	+	+	+	+	+	-
Lonoke County	-	-	-	-	-	-	-	-
Madison County	+	+	+	+	-	+	+	+
Marion County	+	+	+	+	+	+	+	-
Miller County	-	-	-	-	-	-	-	+
Mississippi County	+	-	+	+	+	-	-	+
Monroe County	-	-	-	-	-	-	-	-
Montgomery Co.	-	+	+	-	-	-	+	-
Nevada County	+	+	+	+	+	+	+	+
Newton County	-	+	-	-	-	-	-	-
Ouachita County	-	-	-	+	+	+	-	+
Perry County	-	+	-	-	-	-	-	-
Phillips County	-	-	-	-	-	-	-	-
Pike County	+	-	-	+	+	+	+	-
Poinsett County	+	-	+	+	+	+	+	+
Polk County	+	+	+	+	+	+	+	-
Pope County	-	-	-	-	-	-	-	-
Prairie County	-	-	-	-	-	+	-	-
Pulaski County	-	-	-	-	-	-	-	-
Randolph County	+	+	+	+	+	+	+	+
St. Francis County	+	-	-	-	-	-	-	+
Saline County	-	-	-	-	-	-	-	-
Scott County	+	+	+	+	+	+	+	+
Searcy County	+	-	+	-	-	-	+	-
Sebastian County	+	-	+	-	+	-	-	-
Sevier County	+	+	+	+	+	+	+	+
Sharp County	-	+	-	-	-	-	-	-
Stone County	+	+	-	-	-	-	+	-
Union County	-	-	+	-	+	-	-	+
Van Buren County	-	+	-	-	-	-	-	-
Washington County	-	-	-	-	-	-	-	-
White County	-	-	-	-	-	-	-	+
Woodruff County	+	-	+	+	+	+	+	+
Yell County	+	+	+	+	+	+	+	+

Table 5

Ratio of the individual county's MRS to the state's average MRS

Ratio of the county's MRS to the state average MRS	PC PPTO	Whole sale	Retail	Service	All roads	Person-trips	Hs diploma	Amenity score
Arkansas County	1.03	1.81	0.96	0.96	1.01	0.98	0.99	0.87
Ashley County	0.99	0.53	0.78	0.78	0.86	0.82	0.86	0.74
Baxter County	1.00	0.65	1.04	1.09	0.97	1.11	0.99	1.26
Benton County	1.06	0.80	1.14	0.95	1.07	1.09	1.19	1.25
Boone County	1.07	2.54	1.08	1.05	1.04	1.11	1.10	1.17
Bradley County	0.88	1.34	0.84	0.87	0.87	0.80	0.82	0.81
Calhoun County	0.84	0.11	0.35	0.47	0.72	0.56	0.54	0.66
Carroll County	0.92	0.08	0.98	0.97	0.93	1.09	0.88	1.04
Chicot County	0.97	1.79	0.97	0.95	0.99	0.96	0.99	0.92
Clark County	1.01	0.63	1.04	1.02	0.98	1.03	0.94	1.10
Clay County	0.82	1.76	0.82	0.76	0.87	0.81	0.82	0.49
Cleburne County	0.99	1.03	1.09	1.09	1.01	1.14	0.99	1.16
Cleveland County	0.95	1.47	0.92	1.05	1.05	0.88	0.93	1.00
Columbia County	1.03	0.87	0.96	0.92	0.93	0.93	0.97	0.84
Conway County	1.00	1.26	1.02	1.01	0.96	0.98	0.97	0.89
Craighead County	1.09	1.57	1.13	1.17	1.10	1.15	1.24	0.59
Crawford County	0.92	1.27	1.00	0.97	0.95	1.00	1.08	1.09
Crittenden County	1.16	1.99	1.40	1.36	1.22	1.41	1.39	1.10
Cross County	0.95	1.53	1.01	0.92	0.96	0.93	1.00	0.89
Dallas County	0.86	0.65	0.87	0.87	0.84	0.77	0.74	0.76
Desha County	1.16	1.39	1.06	0.97	0.97	1.00	1.02	0.91
Drew County	0.89	0.83	0.91	0.83	0.87	0.86	0.84	0.79
Faulkner County	1.01	0.82	1.03	1.07	1.01	1.07	1.17	0.88
Franklin County	1.06	0.19	1.01	1.00	1.02	0.96	1.02	1.19
Fulton County	1.04	0.74	1.14	1.20	1.19	1.16	1.03	1.36
Garland County	1.33	1.81	1.50	1.57	1.41	1.65	1.55	1.48
Grant County	0.93	0.53	0.88	0.82	0.87	0.75	0.89	0.79
Greene County	0.82	1.02	0.90	0.89	0.86	0.82	0.92	0.78
Hempstead County	0.91	0.82	0.88	0.91	0.89	0.94	0.90	0.81
Hot Spring County	0.96	0.84	0.99	0.94	0.96	0.94	1.01	1.09
Howard County	0.90	0.38	0.68	0.70	0.77	0.67	0.74	0.89
Independence County	0.96	1.15	0.88	0.95	0.90	0.93	0.96	1.03
Izard County	1.01	1.07	1.02	1.10	1.05	1.02	0.94	1.23
Jackson County	1.05	1.31	1.09	1.11	1.02	1.00	1.00	0.93
Jefferson County	1.15	1.48	1.11	1.15	1.11	1.19	1.31	0.95
Johnson County	0.85	0.12	0.94	0.83	0.85	0.87	0.82	1.14
Lafayette County	0.92	0.44	0.92	1.02	0.96	1.00	0.88	0.93
Lawrence County	0.95	1.35	0.99	0.94	0.95	0.96	0.94	0.88

Lee County	1.16	1.38	1.22	1.25	1.27	1.03	1.15	1.15
Lincoln County	1.03	0.54	0.85	0.98	1.01	0.87	0.95	0.96
Little River County	1.20	0.30	0.85	0.74	0.84	0.86	0.83	0.80
Logan County	0.83	0.43	0.90	0.85	0.91	0.82	0.89	1.03
Lonoke County	1.09	1.51	1.18	1.15	1.15	1.12	1.25	1.00
Madison County	0.92	0.23	0.91	0.95	1.04	0.89	0.92	0.92
Marion County	0.86	0.30	0.82	0.93	0.88	0.93	0.79	1.18
Miller County	1.12	1.76	1.19	1.24	1.07	1.22	1.19	0.97
Mississippi County	0.92	1.23	0.88	0.83	0.94	1.00	1.02	0.80
Monroe County	1.14	2.12	1.34	1.19	1.12	1.25	1.07	1.07
Montgomery County	1.02	0.69	0.97	1.08	1.07	1.09	0.88	1.24
Nevada County	0.95	0.26	0.95	0.96	0.96	0.93	0.90	0.89
Newton County	1.10	0.57	1.09	1.35	1.31	1.23	1.10	1.21
Ouachita County	1.01	1.31	1.05	0.97	0.95	0.99	1.03	0.86
Perry County	1.36	0.90	1.29	1.54	1.45	1.38	1.30	1.70
Phillips County	1.18	2.09	1.23	1.28	1.15	1.19	1.25	1.06
Pike County	0.99	1.21	1.05	0.95	1.00	0.98	0.89	1.16
Poinsett County	0.90	1.67	0.92	0.82	0.97	0.89	0.96	0.53
Polk County	0.91	0.62	0.94	0.91	0.95	0.91	0.89	1.05
Pope County	1.00	1.18	1.08	1.08	1.05	1.14	1.15	1.15
Prairie County	1.31	1.78	1.22	1.20	1.20	0.98	1.04	1.11
Pulaski County	1.57	2.87	1.45	1.60	1.57	1.83	2.03	1.58
Randolph County	0.83	0.97	0.89	0.86	0.87	0.85	0.84	0.80
St. Francis County	0.97	1.75	1.12	1.09	1.05	1.11	1.11	0.96
Saline County	1.17	1.32	1.32	1.27	1.22	1.19	1.37	1.33
Scott County	0.76	0.53	0.82	0.74	0.85	0.75	0.70	0.97
Searcy County	1.00	1.21	1.00	1.07	1.06	1.01	0.90	1.25
Sebastian County	0.99	1.35	0.93	1.01	0.92	1.06	1.14	1.02
Sevier County	0.89	0.87	0.86	0.83	0.85	0.83	0.80	0.78
Sharp County	1.51	0.92	1.86	1.81	1.67	1.70	1.66	1.90
Stone County	1.00	0.60	1.20	1.15	1.05	1.22	0.93	1.26
Union County	1.06	1.13	0.97	1.01	0.99	1.05	1.08	0.86
Van Buren County	1.15	0.19	1.30	1.29	1.21	1.30	1.09	1.60
Washington County	1.06	1.51	1.09	1.07	1.11	1.22	1.31	1.15
White County	1.06	1.23	1.21	1.13	1.13	1.09	1.23	0.95
Woodruff County	0.97	3.06	0.89	0.91	0.97	0.86	0.90	0.94
Yell County	0.82	0.25	0.72	0.75	0.87	0.76	0.82	0.96

Appendix

From the text, we have the following production function:

$$\text{Ln P } (\hat{o}_{it}) = \ln a_{0t} + \sum_{j=1}^{13} a \ln \hat{o}_{it} + \omega = \beta_0 + \sum_{j=1}^{13} b_{it}\, c_{it} + \upsilon,$$

where:

P – gross county product;

o_{it} – i-th independent variable for the t-th year;

c_{it} – natural log of the i-th independent variable for the t-th year;

$ß_{it}$ are the parameters to be estimated in the model; and

? and ? – are the error terms.

Definition of substitutional and nonsubstitutional inputs: Two inputs c_{jit} and c_{kit} are substitutional, if sign of β_{jt} equals sign of β_{kt} with the marginal rate of substitution of:

$$MRS_{jkit} = - \partial\, c_{jit} / \partial\, c_{kit} = \beta_{kt}\, c_{kit}^{-1} / \beta_{jt}\, c_{jit}^{-1} > 0,$$

where

j = 1, 2, . . .,m,

k = 1, 2, . . ., m,

$j \neq k$,

t = 1, 2, . . ., T,

i = 1, 2, . . ., n.

Two inputs are non-substitutional when the sign of β_{jt} does not equal to the sign of β_{kt} .

Formula 1. Estimation of an average marginal rate of substitution:

$$\overline{MRS}_{jkt} = b_{kt} \cdot (1/n\sum_{i=1}^{m} \hat{c}_{kit})^{-1} / b_{jt} \cdot (1/n\sum_{i=1}^{m} \hat{c}_{jit})^{-1}$$