APPLICATION OF MULTIVARIATE ANALYSIS TO DETERMINE INFLUENCE OF RESOURCE BASE ON CHANGES IN ECONOMIC ACTIVITY 1960-70

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Public investments in natural resources have been used as a means to increase the economic base of specified areas and consequently to increase incomes and economic activity in affected areas. The proposed Principles for Planning Water and Land Resources [11] makes explicit a national objective of natural resource development: To enhance regional development through increases in a region's income, increases in employment and improvement of the area's economic base. The existing resource base and subsequent natural resource investments have been shown to exert an influence on economic activity [1, 2, 5, 6, and 8]. A better understanding is needed of the effect of natural resource investments on the enhancement of increases in income, employment, and other economic activities. A measure of these effects would aid public and private agencies in establishing policy which influences investment decisions. The effect of different investments on development of the resource base is an important consideration in policy decisions.

The application of multivariate statistical techniques was useful in the development of homogeneous groups of counties, a single valued resource base index and single valued indices of economic activity for use in estimating the impact of resource investments. Principal component analysis was used to develop numerical indices indicative of the resource base and economic activity for individual counties. Discriminant analysis provided a classification of counties as probably belonging to a homogeneous group. The indices and the homogeneous classification procedures permitted the use of regression techniques to analyze the effect of resource base on economic activity changes.

PRINCIPAL COMPONENT ANALYSIS

Social and economic variables, thought to be indicative of a county's resource base were subjected to principal component analysis for determining weights to be used in developing a single valued index. Each of the variables could be treated as a single indicator of the resource base. However, the assumption that any one indicator is adequate as the sole indicator is without justification. When used separately, these indicators have different results and one indicator could not be judged to be better than another. A wide variation also existed in the rank order among the nine indicators.

Although we have no a priori way for constructing an index, we are able to identify variables which might be included. Since one indicator could not be judged as better than another, each indicator was assigned weights through principal component analysis and combined to produce a single index of resource base. These indices permit statistical analysis which could otherwise become extremely burdensome and computational time consuming if the original set of observations is used rather than the single valued index. The same procedure was used to develop a single valued index for classifications of changes in economic activity.

Principal component analysis divides the selected indicators into independent sources of variation and thus provides a logical weighting scheme for the selected indicators used in the composite index. The objective is to extract the maximum variance and thus to extract the maximum contribution to the sum of the variance of the utilized variables.

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The 19 (stock and flow) resource base variables listed in Table 1 for the 77 northernmost counties in Georgia were selected for the principal component analysis. These variables were selected as being representative of a county's economic base. Harman [4] and Tintner [9] provide a comprehensive discussion of principal component analysis. The validity of the methodology depends to a large extent upon the rational and logical selection of relevant variables. Of the variables available from secondary sources, these nineteen were selected. The variables were representative of land area and use, population distribution, employment by sectors, educational levels, earnings and income distribution. These variables represent the many dimensions in the make-up of a resource base. Other variables were deleted because of a high correlation with included variables or were deleted in the principal component analysis.[1]

The third column in Table 1 gives the factor coefficients (usually called loadings) which indicate the degree and direction of the relationship of the variable with the component pattern. This first component is the largest root of the characteristic equations and is representative of the resource base of each county. The factor coefficients indicate that the index is highly related to most of the variables selected as indicative of the resource base. Percent land urban and buildup, population per square mile, percent families with income less than $3,000 and median school years completed were highly related to the resource base index. These factor coefficients (used as index weights) are multiplied by corresponding standardized variables and summed to obtain each county index value. The county values for the single valued index ranged between 5.15 and −9.66.[2] The index represents a range of relative values for level of resource base.

DISCRIMINANT ANALYSIS

The same 19 variables were submitted to discriminant analysis so that three homogeneous groups of counties were delineated. Discriminant analysis provides a linear combination of various measurements which best discriminate between groups by finding a linear function of the differences of the means. The resource base index could provide a subjective trichotomy; however, with discriminant analysis the researcher can place more confidence on the grouping of counties into homogeneous groups. Such a classification permits the use of dummy variables to estimate the significance of each base group on changes in economic activity.

The last three columns in Table 1 give the coefficients or weights in each linear function for each variable by groups. These linear functions best discriminate between groups. As a result of discriminant analysis, 25 counties were classified as having a high resource base or as being highly developed economically. Twenty-eight counties had a medium base and 24 had a low base or were the least economically developed counties in 1960.

INDICES OF INCOME AND ECONOMIC CHANGE

Since one variable such as per capita income or median income is not indicative of overall changes in income or economic activity, a single valued index was developed to represent many dimensions of changes in income and another index for changes in overall economic activity. The same principal component procedure was used as that for developing the resource base index.

Per capita income or median income alone does not provide an accurate indication of income distribution; thus, several income measures including salaries, earnings, and transfer payments were judged appropriate to represent an index of income changes. Seventeen variables selected as being indicative of overall changes in income were submitted to principal component analysis. Other variables were deleted because they were highly correlated with included variables or were deleted in the principal component analysis.[3] The first and largest component is a single valued representation of changes in income. As shown in Column 3, Table 2, the factor coefficients, which indicate the degree and direction of relationship of the variable with the component pattern, indicate that all seventeen variables were significantly related to the component index. Wages and salary, total earnings, non-farm and total personal income were

[1] Other variables such as service or wholesale and retail earnings were highly correlated (99 percent) with other income variables and deleted from the analysis. Also, percent land in cropland and forest, percent unemployment, percent labor force working outside county of residence were deleted because they loaded less than .10 on the principal component [3, 7].

[2] The index can be placed on another numerical scale such as 100 for the mean values. However, for our analytical purposes this was not necessary.

[3] Other variables including per capita service receipts, service earnings, transportation and communication earnings and unemployment were deleted from the analysis because they were highly correlated (greater than 0.95) with included variables or they loaded less than .10 on the first principal component.

Table 1. NINETEEN VARIABLES USED TO DEVELOP RESOURCE BASE INDEX, 77 COUNTIES, GEORGIA, 1960.

	Variable	Relationship to First Principal Component[a]	Weight Coefficients in Discriminant Function 1	2	3
1.	Percent Land Urban and Buildup	.84	3.6	2.8	2.9
2.	Percent Land Small Water Area	.49	17.0	15.2	11.2
3.	Percent Land Class I-IV	.11	2.7	2.8	2.8
4.	Population Per Square Mile	.86	–0.4	–0.3	–0.3
5.	Non-Worker/Worker Ratio	–.57	203.8	210.1	217.4
6.	Percent Labor Force Employed Manufacturing	–.11	10.6	10.5	10.6
7.	Percent Family Income Less Than $3,000	–.82	5.6	5.7	6.0
8.	Median School Years Completed	.87	89.1	85.6	85.4
9.	Percent Labor Force Employed Agriculture	–.75	13.6	14.0	13.7
10.	Percent Labor Force Employed Services	.47	14.5	14.3	13.8
11.	Value Added in Manufacturing Per Employee	.64	13.0	11.2	11.3
12.	Wages and Salary as Percent Total Income	.74	8.3	8.4	8.2
13.	Property Income as Percent Total Income	.24	1.4	1.2	1.1
14.	Farm Earnings as Percent Total Earnings	–.78	2.3	2.4	2.9
15.	Manufacturing Earnings as Percent Total Earnings	.17	–3.4	–3.7	–3.9
16.	Per Capita Income	.75	–0.1	–0.1	–0.1
17.	Percent Population 18–64 Years	.67	41.2	41.4	41.1
18.	Percent Labor Force Employed by Local Government	.17	0.2	0.3	0.2
19.	Government Earnings as Percent Non-Farm Earnings	–.37	–5.4	–5.8	–5.7

Source: Calculated from secondary data for each county. Variables 1-3: USDA-SCS, Georgia Conservation Needs Inventory, April 1970; Variables 4-10 and 17-18: U.S. Department of Commerce, Population Census, 1960; Variable 11: City and County Data Book; Variables 12-16 and 19: U.S. Office of Business Economics Tape Listout 1929-70.

[a]These factor coefficients indicate the contribution of the first component to the variance of each observed variable. The coefficients are called loadings and represent the degree and direction of the relationship of the variables with the component pattern (the largest root of the characteristic equations). Some authors prefer to delete variables with small values.

Table 2. SEVENTEEN VARIABLES USED TO DEVELOP INDEX OF INCOME CHANGES, 77 COUNTIES, GEORGIA, 1960-70.

	Variable[a]	Relationship to First Principal Component[b]	Weight Coefficient in Discriminant Function 1	2	3
1.	Total Personal Income as Percent U.S.	.59	2.21	1.41	1.22
2.	Total Wages & Salary	.93	−.27	−.38	−.50
3.	Proprietor Income	−.16	.11	.03	.00
4.	Property Income	.38	−.15	−.13	−.18
5.	Transfer Payments	.65	.38	.41	.50
6.	Total Earnings	.87	−.80	−.64	−.75
7.	Total Non-Farm Earnings	.92	.52	.45	.57
8.	Government Earnings	.32	.11	.13	.15
9.	Total Federal Earnings	.46	−.01	−.01	.00
10.	Private Non-Farm Earnings	.76	.05	.07	.08
11.	Manufacturing Earnings	.65	.00	.01	.01
12.	Construction Earnings	.38	−.01	−.01	−.03
13.	Wholesale & Retail Trade Earnings	.62	.16	.13	.15
14.	Service Earnings	.39	−.07	−.02	−.05
15.	Per Capita Personal Income	.27	.79	.76	.98
16.	Total Personal Income	.80	.33	.27	.28
17.	Change Farm Earnings	−.16	−.06	−.03	−.02

Source: Calculated for each county from information obtained on U.S. Office of Business Economics tape printout 1929-70. Personal Income by Major Sources and Earnings by Brood Industrial Sector, Counties, Georgia 1929-70.

[a]Measured in terms of percentage change in variable from 1960 to 1970.

[b]These factor coefficients indicate the contribution of the first component to the variance of each observed variable. The coefficients are called loadings and represent the degree and direction of the relationship of the variables with the component patterns (the largest root of the characteristic equations).

highly related to the index. The factor coefficients, Column 3, Table 2, are multiplied by corresponding standardized variables and summed to obtain each county index value. The single valued index ranging between 3.39 and −6.73 represented a relative value of income changes for each county.

These variables also were submitted to discriminant analysis to delineate three homogeneous groups. The last three columns in Table 2 give the coefficients or weights in each linear function for each variable for each group. Twelve of 77 counties were classified as having high changes in income, 24 had medium changes and 41 had low levels of change.

A second economic activity index was developed to represent general changes in all economic activity. Five variables – value added manufacturing, service receipts, wholesale-retail trade, total employed and farm earnings – were selected to represent changes in overall activity. These five measures of change represent changes in economic activity in various sectors of the economy. Changes (1960-70) in these five variables were submitted to principal component analysis in order to get a single valued index of economic change. The values of Column 3, Table 3, indicate that percentage change in wholesale and retail trade is highly related to the first component. A large amount of variation in value added in manufacturing and total employed is explained by this component. The single valued principal component index ranged from 4.34 to −4.06. The index provides a relative value for changes in economic activity among counties. Also, three groups

Table 3. FIVE VARIABLES USED TO DEVELOP INDEX OF ECONOMIC CHANGE, 77 COUNTIES, GEORGIA, 1960-70.

	Variable[a]	Relationship to First Principal Component	Weight Coefficient in Discriminant Function 1	2	3
1.	Value Added Manufacturing	.74	3.66	−3.05	−1.60
2.	Service Receipts	−.10	.39	−.21	−.01
3.	Retail Trade	.86	−.06	−2.30	−1.32
4.	Total Employed	.74	.15	.53	.35
5.	Farm Earnings	−.27	.02	.02	.02

Source: Calculated from secondary data.

[a]Measure of change is percentage change in variable from 1960 to 1970.

Table 4. REGRESSION OF INCOME CHANGES INDEX ON RESOURCE BASE, 77 COUNTIES, GEORGIA.

Equation Number	Variable	Constant	Regression Coefficient	F Value	Student's t	R^2
I	Resource Base Index	−.0006	.28 (.07)	14.1*		.16
II	High Group Base	.15	.21 (.12)	5.1**	1.78	.17
	Medium Base Dummy X Continuous Base[a]		−.23 (.48)		−.47	
	Low Base Dummy X Continuous Base[a]		.18 (.22)		.81	

*Significant at 1 percent level
**Significant at 5 percent level
[a]No significant difference between medium and low base

of homogeneous counties were delineated by using discriminant analysis.

APPLICATION OF INDICES

Government programs have been implemented with the specific objective of improving the resource base of an area in order to augment incomes or to improve the economic activity of these areas. Indices of resource base, changes in income and economic activity were calculated for this study. Two applications of these indices as developed from multivariate analysis techniques are employed in this paper to test the hypothesis that resource base and investments designed to change the resource base have had a significant impact on changes in income and economic activity.

The single valued nineteen variable resource base index in conjunction with dummy variables to account for the three levels of discriminated homogeneous groups of counties was used to explain changes in income as represented by the seventeen variable income index. A regression model to include a separate set of dummy variables for both the intercept and slope in the same equation would be systematically correct. However, because of the limited sample in each group, such a model could easily encounter an estimation problem due to a high degree of interaction among the dummy variables.

As shown in Table 4, the resource base is

significant at the 1 percent level in explaining variation in the income index. The income index increased by an average 0.28 with each unit change in the resource base index. Equation II shows no significant differences at the 5 percent level between the slopes of the high base and medium or low base groups. Also, there was no significant difference at the 5 percent level between the slopes of the medium and low base groups.

The single valued resource base index was also used to explain variation in the index for overall economic activity. As shown in Table 5, the index of increases in economic activity increased an average of 0.27 for each unit increase in the economic base. As shown by Equation II, there was no significant difference at the 5 percent level among the slopes. This means that changes in the dependent variable as a result of changes in the independent variable were not different for the three groups. We can conclude from this analysis that a higher level of resource base does result in a higher level of change in economic activity, although the rate of change was not significantly different at the 5 percent level for the three groups.

Public investments in natural resources have been used as a means to increase the economic base of communities and consequently increase incomes and economic activity in affected counties. Total public investment for 5 natural resource investment categories -- Corps of Engineers, SCS, National Forest Service, ASCS, and FHA -- in each of the 77 counties for the years 1960-70 was used to explain variation in the incomes change and changes in economic activity indices.[4] The total expenditures for these categories ranged from $40 million in Murray County to $200 thousand in Dekalb County.[5] As shown in Table 6, total expenditure was significant at the 5 percent level in explaining changes in the income index. The index increased by .04 with a $1,000 unit increase in total expenditures. The constant for the low base group was significantly lower at the 1 percent level than for the other two groups but the slopes (not shown in Table 6) among the three were not significantly different. Although the low base groups were at a lower income level, their changes in income did not respond any differently than the other groups.

Total expenditure in natural resources was used also to explain variation in the economic change index. As shown in Table 7, total expenditures were significant at the 1 percent level in explaining changes in economic activity. The economic activity change index increased by .03 with a unit increase in expenditures. The constant for both the medium

Table 5. REGRESSION OF CHANGES IN ECONOMIC ACTIVITY ON RESOURCE BASE, 77 COUNTIES, GEORGIA.

Equation Number	Variable	Constant	Regression Coefficient	F Value	Student's t	R^2
I	Resource Base Index	.0003	.27 (.05)	32.0*		.30
II	High Group Base	.22	.18 (.08)	11.8*	2.32**	.33
	Medium Base Dummy X Continuous Base[a]		.40 (.31)		1.27	
	Low Base Dummy X Continuous Base[a]		.21 (.14)		1.49	

*Significant at 1 percent level
**Significant at 5 percent level
[a]No significant difference between medium and low base

[4] Portions of the expenditure data were obtained from Mr. James Cato, NRED, ERS, University of Florida.

[5] The *Engineering News Record* price index was used to place expenditures on a 1968 base.

Table 6. REGRESSION OF INCOME CHANGES INDEX ON INVESTMENTS IN NATURAL RESOURCES, 77 COUNTIES, GEORGIA, 1960-70.

Equation Number	Variable[a]	Constant	Regression Coefficient	F Value	Student's t	R^2
	(High Base Group) Total Expenditure					
I	Natural Resources	.38	.04	2.91**	1.02	.11
			(.03)			
	Dummy for Medium Res. Base	−.11			−.23	
		(.50)				
	Dummy for Low Res. Base	−1.34			−2.58*	
		(.52)				
	(Low Base Group) Total Expenditure					
II	Natural Resources	−.96	.04	2.91**	1.02	.11
			(.03)			
	Dummy for High Res. Base	1.34			2.58*	
		(.52)				
	Dummy for Medium Res.Base	1.23			2.43*	
		(.51)				

*Significant at 1 percent level
**Significant at 5 percent level
[a]There was no significant differences in the slopes of the three groups.

group and the low group was significantly lower at the 1 percent level than that for the high resource base group. Even though the low base group was significantly different at the intercept (lower level of impact) there was no significant difference in the slopes (not shown in Table 7) of the three groups. The results indicate that changes in the dependent variable as a result of changes in the independent variable were not different among the three groups. However, the level of the effect was significantly higher in the high resource base group. Also, the medium group had a higher level of effect than occurred in the low base group.

SUMMARY

Principal components and discriminant analysis techniques were used to develop indices to analyze the effect of both different levels of resource base and natural resource investments on changes in income and economic activity. A single valued index was developed to represent the resource base of each county and three homogeneous groups of counties were delineated with the first group as the high resource base group. In addition, single valued indices were developed for changes in income and changes in economic activity.

Initial level of resource base was statistically significant in explaining variation in changes in the income index. However, changes in the dependent variable as a result of changes in the independent variable were not significantly different among the three groups. A unit increase in level of resource base corresponded to 0.28 increase in the index of income changes. Level of resource base was significant also in explaining changes in overall economic activity. The economic activity change index increased 0.27 with an increase in level of resource base, whereas, the regression coefficients were not significantly different for each group.

Total public investment for five natural resource investment categories was significant in explaining variation in both the income change index and the overall economic activity index. Income and

Table 7. REGRESSION OF ECONOMIC CHANGE INDEX 1960-70 ON TOTAL INVESTMENTS NATURAL RESOURCES, 77 COUNTIES, GEORGIA, 1960-70.

Equation Number	Variable[a]	Constant	Regression Coefficient	F Value	Student's t	R^2
	(High Base Group) Total Expenditure					
I	Natural Resources	.70	.03	9.2*	1.19	.27
			(.02)			
	Dummy for Medium Res. Base	−.62			−1.93	
		(.31)				
	Dummy for Low Res. Base	−1.71			−5.14*	
		(.33)				
	(Low Base Group) Total Expenditure					
II	Natural Resources	−1.01	.03	9.2*	1.19	.27
			(.02)			
	Dummy for High Res. Base	1.71			5.14*	
		(.33)				
	Dummy for Medium Res. Base	1.09			3.37*	
		(.32)				

*Significant at 1 percent level

[a]There was no significant differences in the slopes of the three groups.

economic activity increased with increases in total natural resource expenditures. Although the intercept or level of change for the low base group was significantly lower than the high or medium base group, their (regression coefficients) rate of change in income and economic activity did not respond differently than the other groups.

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