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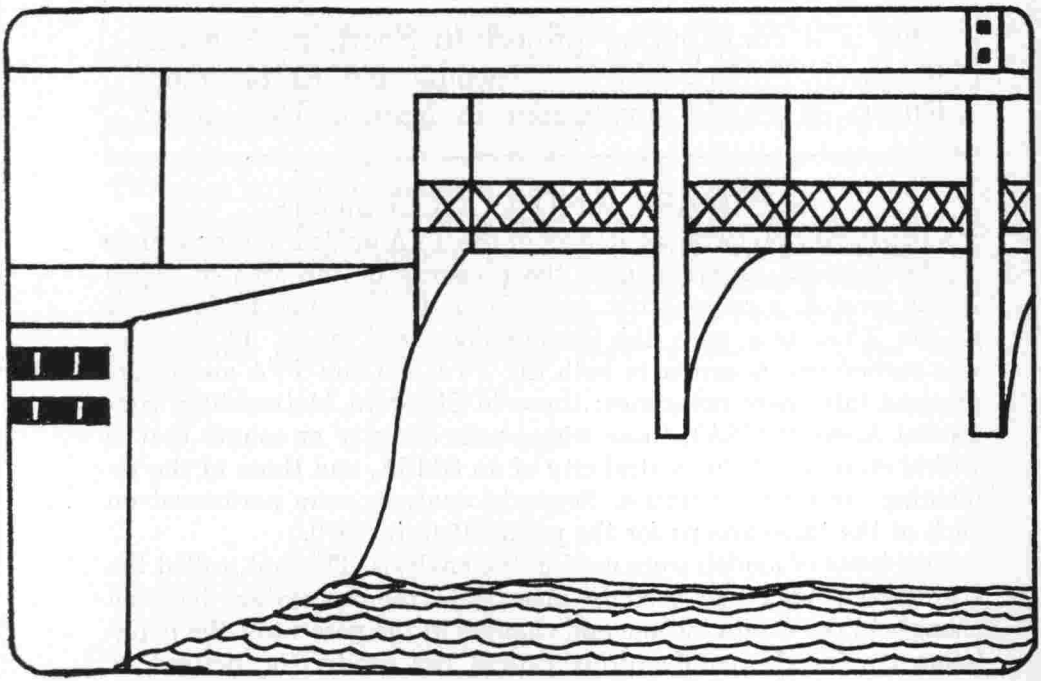

The Economic Impact of Public Investment in Water Resources

A Comparative Analysis of the Tennessee Valley with Surrounding Areas of Six Southeastern States, 1940-1970

A. Eugene Hileman and Joe A. Martin

The University of Tennessee / Agricultural Experiment Station / John A. Ewing, Dean / Knoxville

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SUMMARY AND CONCLUSIONS

IN ORDER TO EVALUATE the impact of the TVA unified water resource development program upon the economy of the area in which it was located, a comparative analysis of the economic performance of the TVA area with the surrounding area in six TVA states was carried out. Counties in both the TVA and non-TVA areas were grouped into three categories: those in Standard Metropolitan Statistical Areas (SMSA), those whose principle city or county seat is within 60 miles of the central city of an SMSA, and those in the remaining hinterland counties. Separate analyses were performed on each of the three groups for the period 1940 to 1970.

Two types of models were used in the analysis. The first, called the structural model, was used to investigate the association between changes in per capita income and changes in the percent of the population employed, manufacturing capital per capita, the percent of employment in agriculture, and the education level of the population. Coefficients estimated for TVA and non-TVA counties were compared to evaluate the impact of the TVA water resource development program upon the economy. The second model was used to analyze differences in the level of the variables between TVA and non-TVA counties for those variables included in the structural model.

The analysis supports the following general conclusions:

1. The greatest impact of the TVA water resource development program was in the counties most remote from urban population centers and least in the SMSA counties. Significantly higher income existed in the hinterland counties in the TVA area in 1970 due to favorable movements in the manufacturing capital per capita and more rapid adjustment out of agriculture over the study period. The commute counties in the TVA area had significantly lower per capita income in 1940, 1950, and 1960, but this had been overcome by 1970.

2. The economic structure of the SMSA and hinterland counties shows no evidence of impact by TVA programs, but substantial differences in the economic structure of the commute counties developed during the period studied.

3. Manufacturing capital per capita was the variable most influenced by TVA. Although comparable in 1940, the amount of manufacturing capital per capita was significantly higher in the TVA area than in the non-TVA area for all three categories of counties in 1970. Manufacturing capital investment was also significantly higher in the TVA area in 1960 for hinterland and SMSA counties.

4. Substantial lags exist between the introduction of a unified water resource development program and demonstrable inpact on the economy of a region. There is indication that long-term trends have been occurring, but they appear to be so slow that very few statistically significant differences were revealed until the 1970 Census.

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THE ECONOMIC IMPACT OF PUBLIC INVESTMENT IN WATER RESOURCES: A COMPARATIVE ANALYSIS OF THE TENNESSEE VALLEY WITH SURROUNDING AREAS OF SIX SOUTHEASTERN STATES, 1940-1970

A. Eugene Hileman and Joe A. Martin*

IN 1973 the Tennessee Valley Authority (TVA) entered its fifth decade of operation. Since its inception, TVA has been charged with promoting economic development of the Tennessee Valley. It has worked toward its objectives by carrying out a unified program[1] of resource development in its area of operation. Millions of dollars have been invested for programs that included hydro and steam electricity generation, community development, watershed development, test demonstration and rapid adjustment farms, river channel improvement and maintenance, and recreational resource development.

TVA did not come as an unmixed blessing in the lives of people in the Valley. Numerous people have been forced to give up their homes and land while others have been employed in nonfarm occupations; dams have flooded thousands of acres of land while development of new agricultural practices and increased flood control have improved the productivity of other millions of acres. Justification for disturb-

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[1]The term unified program is used in this study to refer to a coordinated and comprehensive plan of river basin development. Included among the specific tasks in the project were flood control, electric power generation, river navigation, and erosion control. This differs from other approaches where different phases of river basin development are under the management of different agencies which may or may not put forth a coordinated effort.

ing the lives of a small minority of the population is generally stated in terms of benefits to the great majority.

In order for the TVA experiment to benefit society in planning for the future, policy makers must know whether or not a unified program of water resource development such as that used by TVA is superior to alternative courses of action. If it is determined that such a program did in fact foster economic development, additional questions must be raised to determine the links between the action taken and the positive and negative results obtained.

PURPOSE AND OBJECTIVES

The purpose of the study was to investigate the impact of a unified water resource development program upon economic variables in the area in which the program was operated. The specific objectives of the study were:

1. To investigate the effect of a unified water resource development program upon the structural parameters of the economy of the area in which it operated by use of a multiple regression model comparing the Tennessee Valley area with a check area comprised of selected non-TVA counties in the seven TVA states.[2]

2. To investigate the effect of a unified water resource development program upon per capita income and the quality or quantity of selected resources in the economy of the area in which it operated by use of the analysis of variance. By the use of this technique, a comparison was made of the two areas described in objective one for the variables per capita income, manufacturing capital per capita, percent of employment which is in agriculture, and the level of educational achievement by the population 25 years old and older.

3. To investigate the differential impact of a unified water resource development program upon counties at various distances from urban areas. The analysis for objectives one and two were performed on three categories of counties: 1) SMSA counties (i.e., those in Standard Metropolitan Statistical Areas as of December, 1970), 2) counties within a 60-mile radius of an SMSA, and 3) the hinterland counties.

4. To investigate the time dimension of the impact of a unified water resource development program upon the area in which it is carried out by analysis of the impact of time on the structural parameters in the economy and by an analysis of variance of the several variables for the years 1940, 1950, 1960, and 1970.

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[2]TVA designates 201 counties which are either in the Tennessee River Watershed or receive electric power generated by TVA. These counties comprise all of Tennessee and parts of Kentucky, Virginia, North Carolina, Georgia, Alabama, and Mississippi. The TVA area as the term is used in this study is the 201 counties designated by TVA. The term TVA states refers to those listed above.

THE STUDY AREA

The basic question asked in the study was "How does the TVA area presently differ from the situation which would have existed had TVA not been present in the area over the study period?" Ideally this question could be answered by a comparison of the present TVA area with the same area during the same time period without TVA. Since this is obviously not possible, some substitute must be used as a check or control area. The substitute chosen was an area comprised of most of the seven TVA states not included in the TVA area. Counties in the coastal plain of Virginia, North Carolina, and Georgia were excluded from the study area as was approximately the southern one-third of Alabama and Mississippi. These counties were eliminated because it was felt that they would tend to make the composition of the check area less comparable to the TVA area. Figure 1 shows the TVA area and the control area as designated for the study.

The geographic matrix used in the analysis was divided into a number of categories on the basis of the degree of, or association with, urbanization. Figure 1 shows the counties in each of the categories used in the analysis. The specific definitions of the areas are based upon SMSA designation as of July, 1970 (14). Classifications were as follows:

SMSA counties—Counties in Standard Metropolitan Statistical Areas as designated by the U.S. Department of Commerce in 1970 (14).

Commute counties—Counties whose county seat or principal city is within 60 miles of the central city of an SMSA (6).

Hinterland counties—Those counties with county seat or principal city lying 60 miles or more beyond the central city of an SMSA (6).

The rationale for using these categories is that the spatial distribution of economic activity within the TVA region could reasonably be different from that in the control area. Two reasons for this are, first, TVA has cooperated with local industrial development organizations in attracting industry, and second, electric power may be more readily available to industrial customers in more remote parts of the TVA area than in remote parts of the control area. Other less direct reasons for different spatial distribution include possible differences in the distribution of water resources and social and economic differences which may have resulted from TVA involvement in action-oriented programs such as watershed development and test demonstration projects.

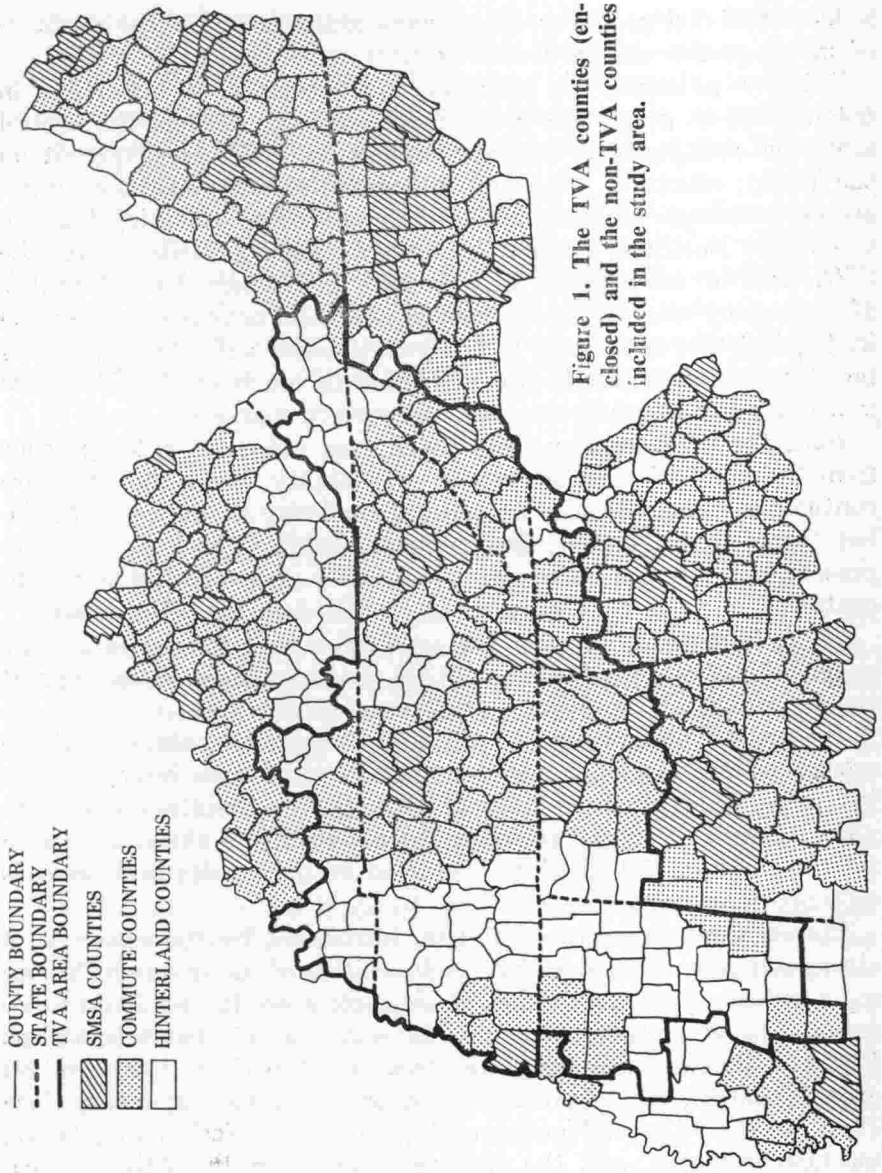

Figure 1. The TVA counties (enclosed) and the non-TVA counties included in the study area.

A number of assumptions are implicit in the research technique used. To avoid misinterpretation of the results, some of the more important of these need to be explained. From the discussion above it follows that, ideally at least, the only difference between the TVA area and the check area is the existence of TVA in one, but not in the other. Clearly this condition is not entirely met due to differences

in locational factors and resource endowments as well as the existence of unique growth centers in each area.

Relative proximity to markets and resources is important in determining an area's rate of economic advance. Because the control area was contiguous to and surrounded the TVA area (except on the West), effects of locational differences should have been minimized—although not completely eliminated. For example, it is obvious that Northern Virginia is at a locational advantage over the TVA area in serving the large market in Eastern United States. However, any bias which this may cause should have been moderated by the fact that such areas as Central Alabama and Mississippi may be at a locational disadvantage relative to much of the TVA area in serving key Northeastern and Midwestern markets.

Both the TVA area and the check area are quite heterogeneous from the point of view of resource availability. Since the areas are contiguous, climate is similar; cultural similarity should cause the labor forces to be similar; and natural resources such as coal are present in both areas (although perhaps they are somewhat more concentrated in parts of Kentucky not included in the TVA area).

There is much to support the contention that the two areas are comparable, however. Social, political, and economic institutions at the beginning of the study period should have been quite similar in the areas. The Southern political tradition existed throughout the areas, and the economy was dominated by agrarian interests. The two areas had a common cultural heritage. The results of some empirical investigation to determine the suitability of the control area for the purposes intended are reported in the results and analysis section of the report.

Biased comparisons could also be introduced by the existence of strong self-generating growth centers in either of the areas which were independent of TVA activities. These factors would be related to location and resources but could, to some extent, be independent forces. Although both the TVA area and the check area contain growth centers, the two centers of extremely rapid expansion since 1940 are the parts of Northern Virginia in the Washington, D. C., metropolitan area, and the Georgia counties in the Atlanta area. To the extent that no comparable growth centers exist within the TVA area, some bias may be introduced.

The assumptions implied in the analysis are important insofar as they concern possible alternatives to the actual situation. In this study, the focus was on the impact of a unified water resources development program such as TVA as compared to alternatives. The

alternatives (which became fact in the check area) include less comprehensive public water resource development such as that carried out by the U.S. Corps of Engineers[3] and private development of hydro and steam electric generation capacity. It is implied that these, or similar programs would have taken place in the Tennessee Valley if TVA had not existed.

There is some evidence to support this contention. For example, the Aluminum Company of America had completed a number of hydroelectric dams on tributaries of the Tennessee River before 1933. Likewise, the U. S. Corps of Engineers has been active in the development of most major rivers in the country including the Cumberland River which is partly within the TVA power service area.

METHODOLOGY AND MODELS

Two associated types of analyses were carried out in the study. First, a structural economic model was used to investigate the relationship between the amount or quality of selected resources and the level of per capita income. This is referred to as the structural model throughout this report.[4] Second, the level of the relevant variables was investigated to determine the influence of public investment in water resources upon the level of variables included in the structural model. This is referred to as the level of variables model throughout the report.

To illustrate the two types of relationships investigated, one can consider the following example. Area A and Area B have the same amount and quality of resources but income in Area A is higher because of the structure of its economy. Area C and Area D have no structural differences which cause different levels of income in the two areas but, because the quantity of private manufacturing capital per capita is higher in C, per capita income is also higher in that

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[3]Actually the Corps of Engineers did some work in the TVA area as defined in this study. Some but not all of their projects were tied into the comprehensive plan of water resource development in the area. For example, Barkley Dam on the Cumberland River is coordinated closely with TVA's Kentucky Dam on the Tennessee River.

[4]This terminology should not be confused with the distinction between structural and reduced form models as the terms are used by econometricians.

area. Separate models were used to investigate these two types of relationships.[5]

Structural Model

The equations estimated for the structural model[6] had the form:

$$\ln X_{1jkl} = b_{1kjl} + b_{2jkl}\ln X_{2jkl} + b_{3jkl}\ln X_{3jkl} + b_{4jkl}\ln X_{4jkl} + b_{5jkl}\ln X_{5jkl} \quad (1)$$

where: ln refers to the natural logarithms of the variable X_{ijkl}. Subscript $_j$ refers to SMSA, commute or hinterland counties; subscript $_k$ refers to TVA or non-TVA counties; and subscript $_l$ refers to 1940, 1950, 1960, or 1970. The variables X_i are defined as follows:

X_1 = per capita income

X_2 = percent of the population employed

X_3 = private capital in manufacturing per capita

X_4 = median school years completed by the population 25 years or older

X_5 = percent of employment which is in agriculture

b_1 is the estimated constant or intercept term while b_2 through b_5 are the estimated regression coefficients.

Separate multiple linear regressions were used to estimate coefficients for TVA and non-TVA areas for 1940, 1950, 1960, and 1970[7] and a test for significant differences in the respective pairs of coefficients for each year was made. This test was to determine whether or not the respective coefficients were estimated from the same population. Rejection of the null hypothesis indicated that a difference in

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[5]Ideally a simultaneous or recursive system of equations could be used to investigate both types of relationships concurrently. Although this was considered, such a model was not deemed feasible due to lack of data for relevant variables. For example, the level of private manufacturing capital could well be influenced by TVA because of a reduction in power costs, the availability of water, or reduced river transportation costs. The data required to estimate a regression equation using these variables is quite difficult to define in a way that is both obtainable and suitable for an economic model.

[6]A similar model was also used to estimate structural parameters in the groups of counties for 1940. In this model, lack of data required that the education variable be changed to percent of population completing high school.

[7]The program used was the *Statistical Analysis System* designed and implemented by A. J. Barr and J. H. Goodnight, University of North Carolina, Raleigh.

the structure of the regional economies was associated with inclusion in the TVA as opposed to the non-TVA groups.[8]

The structural model was designed to investigate links between per capita income and the resources of the economy. Such relationships are numerous and complex but several were judged on *a priori* grounds to be more important and were included in the model.

Percent of the population employed (X_2) reflects a number of things including, among others, the dependency ratio of the population, unemployment, and social attitudes concerning remunerative employment by married women. One would expect a positive relationship between this variable and per capita income. It must be emphasized that the relationship being investigated in this phase of the study is the effect of an incremental change in the independent variable upon per capita income—the absolute level of each notwithstanding.

In addition to the amount of labor per capita (percent of the population employed), the quality of the labor input should be an important determinant of per capita income. As a proxy for quality of labor, median school years completed by the population 25 years old and older was used as an independent variable. One would expect per capita income to increase as the quality of the labor force im-

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[8]The equation used to calculate a t value in the pairwise tests (13, p. 173) was:

$$t = \frac{(b_{i1} - b_{i2})}{[S_p^2 (C_{i1} + C_{i2})]^{1/2}}$$

$$S_p^2 = \frac{Ess_1 + Ess_2}{n_1 + n_2 - 2k}$$

i = o to k = number of b's estimated
1 = TVA
2 = non-TVA

C_{i1}, C_{i2} are the appropriate diagonal elements from the $|X'X| - 1$ matrix for the TVA and non-TVA groups.

N_1, N_2 are the number of counties in the respective TVA and non-TVA groups.

Ess_1, Ess_2 are the error sum of squares from the multiple regression estimates for TVA and non-TVA groups, respectively.

proved since higher quality workers should be more productive and, therefore, receive higher wages.

Capital resources are also very important in determining the level of per capita income in an area. As workers gain additional capital with which to work, their productivity, and, therefore, their wages, should increase. In a closed economy, earnings from private capital resources would also accrue to the population and increase income aside from its effect on wages. Since the economies being dealt with in this study are by no means closed, some, and conceivably all, the earnings accruing from capital resources may flow out of the area. Nonetheless the expected net contribution of additional capital to per capita income would be positive.

Data on the total private capital stock in the economy was not available and an estimate of this variable was not attempted in the study. Rather, the focus was upon private capital in manufacturing. The logic: that manufacturing has tended to be a leading sector with regard to capital accumulation in the economy. A difference in the respective coefficients for this variable could occur between the TVA and non-TVA areas if the TVA investment in social overhead capital made capital in that area more productive. Other factors are likely to have considerable influence on the coefficient, however. Since a cross-section of counties was used to estimate the coefficient, the type of non-manufacturing employment available in the different counties is important. A county with a large proportion of professional and finance employment might have relatively low manufacturing capital per capita but high income while a rural county, where agricultural employment predominates, may have a similar amount of manufacturing capital per capita but have a low income. The effect of this phenomenon should have been minimized by dividing the counties into three subgroups.

It is frequently argued that earnings of labor and capital are lower in agriculture than elsewhere in the economy; therefore, one would expect a negative relationship between the level of this variable and per capita income. This is especially true in areas where economic forces are at work which reduce the optimum number of workers in agriculture and where there is a lag in the adjustment process. The structural relationship could differ among regions, however, due to differences in the type of agriculture (e.g., subsistence as opposed to commercial), or differences in the alternative types of employment (e.g., high wages as opposed to low wages).

Level of Variables Model

The general form of the simple linear model used to investigate variance between the TVA and non-TVA groups was:

$$X_{ijl} = a_{ijl} + b_{ijl}D_w \qquad (2)$$

i = 1 to 5 refers to X_1 to X_5 as defined under the structural model

j = SMSA, commute, or hinterland counties

l = 1940, 1950, 1960, or 1970

D_w = 1 if TV and 0 if non-TVA

a_{ijl} = constant term $\cong$ to the mean of X_{ijl} for non-TVA counties in the group

b_{ijl} = the effect upon a_{ijl} of counties being in the TVA area, i.e., the difference in the means of X_{ijl} between TVA and non-TVA groups

The b coefficients estimated for these equations are of primary interest since they indicate the direction and magnitude of the difference in the level of variable X_{ijl} between the non-TVA and TVA areas. Statistically significant values of this coefficient could indicate a significant influence of the TVA resource development program upon the region in which it operates at the point in time the observations apply.

Treatment of Time in the Analysis

Data were collected for each of the counties in the study area for 1940, 1950, 1960, and 1970. The assumption was made that the 1940 data did not reflect the effect of TVA activity prior to that year.[9] Analysis was performed upon the 1940 data primarily to serve as a basis of comparison and, more importantly, to determine the degree of difference between the TVA area and the check area at the beginning of the period. The data for 1950, 1960, and 1970 were then used to evaluate the impact of TVA. It is important to stress that all the analyses used comparative statics, i.e., comparing the situation in one period with that in some other period. The path of adjustment between periods was not investigated, except insofar as 1950 and 1960 represent measures between 1940 and 1970.

In neither model was time treated explicitly. Rather, it was examined implicitly by comparing the sign, magnitude, and statistical significance of the coefficients estimated for the different years.

[9]This is a reasonable assumption based upon the expected time lags of impact of TVA expenditure reported in Hileman and Martin (3).

No direct comparison of the influence of time was introduced and statistical tests of relationships were not possible. Rather, conclusions regarding time must be drawn by examining the results of the separate analyses for the 4 years. That is, changes in the observed differences over time and patterns in the estimated effect of TVA can be used as a basis for general conclusions regarding time patterns of the impact of investment in water resources. Comparisons between 1940 and the later years is somewhat restricted due to a change in the specific definitions of variables X_1 and X_4, but this was not a problem when comparisons were made between 1950, 1960, and 1970.

DATA

The primary unit of observation was the county. Data for the 527 counties included in the study were gathered from secondary sources. Detailed descriptions of the procedure and sources used in constructing each of the variables included in the analysis are in the Appendix.

Comparability of Data

The problem of lack of comparability of data series at different points in time was encountered in several instances in this study. In 1940, data on county income were reported as gross effective buying income, i.e., personal income (7, 8), while the series for 1950, 1960, and 1970 were entitled net effective buying income, i.e., disposable income (9, 10, 11).

The noncomparability of these series imposed limits on the type of analysis which could be performed. Also, it affected the interpretation of some of the results which were obtained. Obviously, combining observations from 1940 with observations from 1950, 1960, and 1970 to estimate a single equation was not possible. Separate regression equations were estimated for 1940 and, as will be shown later, information was obtained by comparing these results with those for the three subsequent points of time. The estimated values of regression coefficients for 1940 were not strictly comparable with those for 1950, 1960, and 1970, however.

Comparisons of 1940 with 1950, 1960, and 1970 were further restricted because data on median school years completed by persons 25 and over were not available for 1940. As a substitute, the percent of the population 25 and over and who had completed high school was used to reflect the quality of the labor force.

Employment data for 1970 were altered slightly from earlier years

due to a change from 14 to 16 in the minimum age for which data were reported for each separate employment category. Partial adjustment for this change was possible since employment of 14- and 15-year-olds was reported as either agricultural or nonagricultural. Since it is reasonable to assume that employment of 14- and 15-year-olds in manufacturing (the other separate employment category broken out for analysis) was quite small, any error introduced probably was negligible.

Capital in Manufacturing

One of the more troublesome variables used in the analysis was the estimated capital in manufacturing for counties. These data were constructed as described in the Appendix. Briefly, the process was to multiply the number of people employed in each category of manufacturing (11 in all) for the county times the estimated book value of manufacturing establishments per production worker for industries in that category. The latter figure was based on national data and was the same for all counties in any given year.

The data fell short of the ideal in several ways. First of all, using national data for estimates of the capital per worker fails to recognize the variation in capital intensity among plants producing the same product. Second, grouping all manufacturing into 11 categories means that industries of various levels of capital intensity will be found within each category. Only if each county has a mix of industries within the category which is equal to the national average will this not cause some error in the estimates. Third, use of book values may cause estimates to be biased due to depreciation schedules which do not accurately reflect loss of market value of the assets.

Even recognizing its shortcomings, the estimate of capital in manufacturing was believed to be the best available data. Perhaps the figures are not totally accurate for each county but they should reflect the capital intensity of the county's industrial mix as well as the amount of manufacturing employment in the county. Such a variable was felt to be an important determinant of income. From the point of view of the present study, it is an especially important variable since it is likely to be influenced by public programs which lower the cost of production in one area relative to some other area. A unified program of public investment in water resources could affect cost of production by reducing transport cost or the cost of electric power.

Price Levels

Income and the value of capital in manufacturing are both influenced by price levels. Therefore, the question arises concerning the conversion of these variables to a constant dollar basis. One problem which arises in attempting to transform the data is the selection of an appropriate index. A general practice is to use the consumer price index when deflating disposable income. The decision on manufacturing capital is more difficult since, first, the choice of an index is not so clear, and second, the index reflects current costs while the stock of capital at any given time was put in place over many years.

A second problem with using indexes to deflate data for geographic subunits is that a national norm is being imposed. Clearly, prices for all areas do not move together[10] and, therefore, a source of variation among county observations is eliminated.

Since data from different years were used to estimate coefficients for each year separately and since logs were used in the estimation of the structural parameters, the price level problem should only occur when making interyear comparisons in the level of variables model. Even here, being aware of the potential problem should enable one to avoid drawing invalid conclusions.

RESULTS AND ANALYSIS

The 1940 Situation

One of the assumptions made in the study was that, in 1940, the economy of the TVA area was similar to the economy of the counties in the control area. The validity of this assumption was investigated using the same type of analysis as was used in the remainder of the study. The results of the regression analysis of the structural relationships for 1940 are presented in Table 1. Since logarithms of the variables were used in the estimation, the coefficients give the estimated percent change in the dependent variable (per capita income) which was associated with a 1 percent change in the respective independent variables. For example, in the non-TVA counties of the SMSA group a 1 percent increase in the variable, percent

[10]For example, price indexes computed for different cities show substantial variation over time (15).

of the population employed, was associated with a .174 percent increase in per capita income. The comparable figure for the TVA counties in the group was .654 percent.

Table 1. Results of the multiple linear regression using the structural model for 1940

		Independent variables				
	Constant	Percent of population employed[a]	Manufacturing capital per capita	Percent of population completing H.S.[a]	Percent of employment in agriculture[a]	R^2
SMSA						
Non-TVA	-4.100**	.174	.093	.725**	-.208	.71
TVA	-2.434	.654	-.062	.585	-.349*	.89
Commute					x	
Non-TVA	-3.376**	.411**	-.021	.830**	-.272**	.70
TVA	-3.934**	.192	.061	.781**	-.055	.53
Hinterland			x		x	
Non-TVA	-2.347**	1.018**	.103	.431*	-.375**	.74
TVA	-1.861**	.923**	-.054	.403**	-.627**	.72

[a]Coefficients give the percent change in per capita income associated with a 1 percent change in the independent variable.

xCoefficients for the TVA and non-TVA counties were significantly different at the .05 level.

*Coefficients were significantly different from zero at the .05 level.

**Coefficients were significantly different from zero at the .01 level.

The results of two separate tests of statistical significance are reported in Table 1. The usual test for significance of the estimated regression coefficients along with the R^2 gives information on the usefulness of the model in explaining the variations in the dependent variable. The test to determine whether or not the respective coefficients in the TVA and non-TVA equations were estimated from the same population is useful when applied to the 1940 estimates in that it gives insight into the similarity of the TVA area with the control area at the beginning of the study period. If the areas are truly similar, differences which develop in the areas during later periods can be demonstrated by using the results of this test on the estimated coefficients for later years.[11]

The results of the regression analysis of the structural models in Table 1 suggest that for the SMSA group the differences between

[11]Some caution in the interpretation of the result is necessary at this point since failing to show that the estimates were made from different populations does not prove that they were made from the same population.

the TVA and non-TVA counties were not significant; i.e., none of the respective pairs of coefficients were significantly different at the .05 level.[12]

Both the commute and hinterland groups of counties had some coefficients which were significantly different between the TVA and non-TVA counties. A reduction in the percent of employment in agriculture had a significantly greater impact in the non-TVA counties than it did in the TVA counties. This may be because of differences in the type of agriculture or the type of nonfarm employment available for agricultural labor in the two areas. Interpretation is complicated somewhat by the fact that the coefficients estimated for the TVA counties for this variable were significantly higher in the hinterland group but significantly lower in the commute group. In addition to the differences in percent of employment in agriculture, the coefficients estimated for manufacturing capital per capita was significantly higher in the non-TVA counties than in the TVA counties for the hinterland groups.

Table 2 contains the results for 1940 of the analysis using the level of variables model for the three categories of counties included in the study. The table contains two figures for each analysis. The top figure is the estimated mean of the variable for the control, or non-TVA area, while the bottom figure is the difference in the mean of the TVA and non-TVA areas. If the only difference in the two areas was the inclusion of a unified water resource development program in the TVA area, the coefficient would be attributable to this fact. The coefficients in the table are in absolute figures (i.e., they are not percent changes as was true in the analyses using the structural model).

The data presented in Table 2 for the SMSA counties support a hypothesis that these groups of counties were quite similar with respect to the level of the investigated variables in 1940. The only significant difference was in the percent of the population employed which was 2.94 percentage points lower in the TVA area than in the non-TVA area.

More significant differences were demonstrated by analyzing the level of the variables for the commute counties in 1940 than for the SMSA counties. Per capita income and percentage of population

[12]Only 13 SMSA counties were classified as TVA. This limitation on the degrees of freedom may help explain the lack of significance of the regression coefficients for this equation. It may also influence the test for significant differences among the pairs of coefficients for the TVA and non-TVA groups.

Table 2. Results of the analysis of variance for 1940 between TVA and non-TVA groups in the SMSA, commute, and hinterland categories for per capita income, percent of population employed, manufacturing capital per capita, percent of the adult population completing high school, and percent of employment in agriculture

	SMSA	Commute	Hinterland
Per capita income (current dollars)			
Estimated mean of non-TVA	379.43	217.55	163.71
Effect of TVA	-43.20	-59.31**	.08
Percent of the population employed			
Estimated mean of non-TVA	35.57	32.14	29.44
Effect of TVA	-2.94*	-1.51	-1.00
Manufacturing capital per capita (current dollars)			
Estimated mean of non-TVA	406.78	210.04	101.26
Effect of TVA	30.69	-30.77	45.26
Percent of the adult population which has completed high school			
Estimated mean of non-TVA	21.91	13.44	10.84
Effect of TVA	-2.62	-1.37**	1.44**
Percent of employment in agriculture			
Estimated mean of non-TVA	22.32	51.25	58.45
Effect of TVA	4.57	2.02	-.75

*Difference in the two groups significant at the .05 level.
**Difference in the two groups significant at the .01 level.

completing high school were significantly lower in the TVA area. One might hypothesize that the higher income was at least partly attributable to the superior quality of the labor force as demonstrated by the higher education levels in the non-TVA counties in the commute group.

Data in Table 2 show a significant difference between the percent of the population completing high school in the hinterland TVA and non-TVA counties in 1940. Differences in the remaining variables were not significant (at greater than the .05 level) for the hinterland counties in the base year.

The purpose of examining the results of the analyses of the two models for 1940 was to determine the suitability of the control area as a base upon which to investigate the effect of the unified water resource development program in the TVA area. The assumption

that the TVA and non-TVA areas were similar in 1940 appears not to be entirely justified. For SMSA counties, no significant difference between the TVA and non-TVA areas were revealed by the pairwise tests of the regression coefficients estimated in the structural model; likewise, the only variable for which a significant difference was found in the level of variables model was the percent of the population employed.

For the commute counties, however, the coefficients for percent of employment in agriculture were significantly different between the two groups in the structural model; also, educational achievement and, more importantly, per capita income in the commute counties was shown to be significantly lower by the level of variables model. In the hinterland counties, two of the four variables had significantly different coefficients in the structural model but only one variable, the educational achievement, was found to be significantly different in the level of variables model. Although some care must be exercised in interpreting the results of the statistical analysis for 1950, 1960, and 1970 due to these differences at the beginning of the study period, useful comparisons can be made between the TVA area and the non-TVA control area. In cases where significant differences were shown for 1940, the data for later years were examined for an indication of trends which were present.

The Structural Model

The coefficients estimated for the structural model give an indication of the efficacy of the model as a tool for studying the impact of public investment in water resources. To the extent that the model is adequate for dealing with the task at hand, the comparisons of the coefficients for TVA and non-TVA groups reveal the impact or lack of impact of public investment by TVA in different counties.

Table 3 contains the coefficients estimated for 1940, 1950, 1960, and 1970 using the structural model for the TVA and non-TVA counties in the SMSA group. (Coefficients for 1940 are repeated from Table 1 for ease of comparison.) The results of the two tests for statistical significance discussed above are also reported. These data for the SMSA counties show no definitive evidence that the TVA investment has caused a divergence in the structure of the economies in the TVA as opposed to the non-TVA counties. Indeed, not only were no statistically significant differences between the respective pairs of coefficients present; visual examination reveals that most pairs of coefficients were quite similar in sign and magnitude.

Table 3. Coefficients estimated by multiple linear regression using the structural model for SMSA counties for 1940, 1950, 1960, and 1970

		N	Constant	Percent of population employed[a]	Manufacturing capital per capita[a]	Median school years completed[a,b]	Percent of employment in agriculture[a]	R^2
1940	non-TVA	43	-4.100**	.174	.093	.725**	-.208	.71
	TVA	13	-2.434	.654	-.062	.585	-.349*	.89
1950	non-TVA	43	-3.959*	.024	.083	1.409**	-.123*	.5850
	TVA	13	-2.203	.396	-.158	1.511*	-.191**	.9184
1960	non-TVA	43	0.072	.452**	-.142**	.615**	-.145**	.8504
	TVA	13	-1.316*	.431	.062	.583*	-.120**	.9406
1970	non-TVA	43	0.332	1.007**	-.044	0.751	-.040	.4017
	TVA	13	-1.920	0.369	.039	1.152*	-.046	.7848

[a]Coefficients give the percent change in per capita income associated with a 1 percent change in the independent variable.

[b]Due to unavailability of data, percent of population was used for 1940 rather than median school years completed.

*Coefficients were significantly different from zero at the .05 level.

**Coefficients were significantly different from zero at the .01 level.

Manufacturing capital per capita is the variable whose coefficients are the most frequent exception to the above statement. Although the differences between the pairs of coefficients estimated for the variable were not statistically significant, the signs within pairs of coefficients were different in each of the 4 years. The coefficient for TVA counties had a negative sign in 1940 and 1950 while non-TVA counties had a negative sign in 1960 and 1970. More will be said about this variable later in the report, but some inconsistency appears to have been present in the coefficients estimated for this variable.

One pattern that seems to be present in the data for SMSA counties in the TVA as well as the non-TVA groups is the declining size of the negative coefficient estimated for percent of employment in agriculture. This indicates that through time the economies were moving toward an "optimum" situation with respect to the shift of labor out of agriculture. Theoretically, if the optimum level of employment in agriculture was reached, marginal reductions in the percent of employment in agriculture would result in no increase in per capita income.

Unlike the data for SMSA counties, the data for commute and hinterland counties, reported on Table 4 and Table 5, respectively, show some significant differences between paired coefficients. The strongest evidence of a divergence in the structure of the economies of the TVA as opposed to the non-TVA group of counties was in the commute category for 1970. In this case the pairs of coefficients estimated for percent of employment in agriculture and those estimated for median school years completed both revealed significant differences between TVA and non-TVA groups. Substantial difference in the coefficients estimated for percent of population employed also existed, but this difference was not significant at the 1 percent level. All coefficients for these variables were significantly different from zero except percent of employment in agriculture in the non-TVA group.

In general, the patterns in the data reported for commute and hinterland counties were very similar to those discussed for SMSA counties even though some significant differences between paired coefficients were present on Tables 4 and 5. The signs and magnitude of the coefficients estimated for manufacturing capital per capita continued to make their interpretation difficult. Several negative coefficients for this variable were estimated for the commute counties; however, none were statistically significant from zero. In the hinterland counties, all but two of the coefficients estimated for manufacturing capital per capita were negative.

Table 4. Coefficients estimated by multiple linear regression using the structural model for commute counties for 1940, 1950, 1960, and 1970

		N	Constant	Percent of population employed[a]	Manufacturing capital per capita[a]	Median school years completed[a,b]	Percent of employment in agriculture[a]	R^2
							x	
1940	non-TVA	232	-3.376**	.411**	-.021	.830**	-.272**	.70
	TVA	100	-3.934**	.192	.061	.781**	-.055	.53
					x			
1950	non-TVA	232	-2.356**	.819**	.059*	1.151**	-.125**	.5177
	TVA	100	-2.569*	1.104**	-.070	1.703**	-.263**	.5107
							x	
1960	non-TVA	232	-2.126**	.425**	.023	1.174**	-.036*	.5580
	TVA	100	-2.724**	.352**	-.060	1.608**	-.107**	.6254
						xx	xx	
1970	non-TVA	232	-0.584	.478**	.004	.809**	.011	.3474
	TVA	100	0.683	.738**	.021	.220**	-.080**	.4402

[a]Coefficients give the percent change in per capita income associated with a 1 percent change in the independent variable.

[b]Due to unavailability of data, percent of population was used for 1940 rather than median school years completed.

[x]Coefficients for TVA and non-TVA counties were significantly different at the .05 level.

[xx]Coefficients for TVA and non-TVA counties were significantly different at the .01 level.

*Coefficients were significantly different from zero at the .05 level.

**Coefficients were significantly different from zero at the .01 level.

Table 5. Coefficients estimated by multiple linear regression using the structural model for hinterland counties for 1940, 1950, 1960, and 1970

		N	Constant	Percent of population employed[a]	Manufacturing capital per capita[a]	Median school years completed[a,b]	Percent of employment in agriculture[a]	R^2
					x		x	
1940	non-TVA	52	-2.347**	1.018**	.103	.431**	-.375**	.74
	TVA	87	-1.861**	.923**	-.054	.403**	-.627**	.72
				xx				
1950	non-TVA	52	3.006**	2.088**	-.050	-.654	-.355**	.5483
	TVA	87	-0.209	0.974**	.025	.117	-.404**	.5361
							xx	
1960	non-TVA	52	-0.366	.505**	-.015	.446	-.068**	.5506
	TVA	87	-0.758	.536**	-.008	.566**	-.155**	.5860
1970	non-TVA	52	0.973	.794**	-.037	.368	-.020	.5529
	TVA	87	0.514	.915**	-.071	.787**	-.012	.4693

[a]Coefficients give the percent change in per capita income associated with a 1 percent change in the independent variable.

[b]Due to unavailability of data, percent of population was used for 1940 rather than median school years completed.

[x]Coefficients for TVA and non-TVA counties were significantly different at the .05 level.

[xx]Coefficients for TVA and non-TVA counties were significantly different at the .01 level.

*Coefficients were significantly different from zero at the .05 level.

**Coefficients were significantly different from zero at the .01 level.

The coefficients estimated for the percent of employment in agriculture declined over time in both commute and hinterland counties as they did in the SMSA counties. Although substantial contribution to per capita income was associated with adjustment of employment out of agriculture relative to the nonagricultural sector in the earlier years, little or no increase was associated with similar adjustment by 1970.

Level of Variables Model

Table 6 contains the data on the level of variables model for SMSA counties for 1950, 1960, and 1970 as well as the 1940 data. The 1940

Table 6. Results of the analysis of variance between TVA and non-TVA groups in the SMSA category of counties for per capita income, percent of the population employed, manufacturing capital per capita, median school years completed, and percent of employment in agriculture

	1940	1950	1960	1970
Per capita income (current dollars)				
Estimated mean of non-TVA	379.43	1,026.34	1,655.15	2,990.13
Effect of TVA	-43.20	-20.60	-166.53	-239.11
Percent of the population employed				
Estimated mean of non-TVA	35.57	37.77	35.80	40.72
Effect of TVA	-2.94*	-3.02	-.99	-2.94
Manufacturing capital per capita (current dollars)				
Estimated mean of non-TVA	406.78	948.27	1,649.74	2,867.87
Effect of TVA	30.69	160.38	522.48*	960.78*
Percent of the population which has completed high school or median school years completed[a]				
Estimated mean of non-TVA	21.91[a]	8.83	9.92	11.31
Effect of TVA	-2.62	-.23	-.32	.00
Percent of employment in agriculture				
Estimated mean of non-TVA	22.32	13.09	5.56	2.49
Effect of TVA	4.57	6.54	1.98	.44

[a]Due to inavailability of data, percent of population 25 and over who had completed high school was used as a measure of educational achievement in 1940.

*Difference in the two groups significant at the .05 level.

data are repeated from Table 2 on this and the following two tables for ease of comparison.

The most revealing feature of the data is the lack of significant differences in the level of the variables during the period studied. Although the per capita income appears to be growing more rapidly in the non-TVA counties between 1950 and 1970, differences are not significant even in 1970. The educational level acheived in the TVA counties had risen to the level of the non-TVA counties, but even in the earlier years, no significant level of differences in this variable was demonstrated in the data.

The only significant difference in the level of the variables was in manufacturing capital per capita in 1960 and 1970. In 1970 this variable was $961 higher in the TVA area than in the non-TVA area. Even this result is difficult to interpret—especially in light of the frequency of negative coefficients estimated for this variable using the structural model. It could mean that the TVA development program has attracted private manufacturing capital or it could mean that the non-TVA SMSA counties have relied more heavily upon nonmanufacturing employment (e.g., services and finance) as a basis of economic growth. At any rate, one must conclude that, overall, there is very little evidence from this analysis to support an hypothesis that the TVA water resource development program has had a measurable impact upon the SMSA counties.

The data on Table 7 for the level of variables model in the commute counties show a number of patterns which are interesting in assessing the performance of the TVA versus the non-TVA counties. The significantly higher level of per capita income in the non-TVA area in 1940, 1950, and 1960 was eliminated in 1970. One factor which could have contributed to this is the relative changes in manufacturing capital per capita. Although this variable was higher in the non-TVA counties in 1940, 1950, and 1960 (not significant at the .05 level), it was significantly higher in the TVA counties in 1970. The other variable in which a significant difference existed in 1970 for the commute counties was the median school years completed. It was higher in the non-TVA counties, however, and should not have contributed to the higher income in the TVA counties.

Some of the most conclusive evidence of an impact of TVA is shown in the hinterland counties. The level of all variables was significantly different between the two groups in 1970 (Table 8). Per capita income, which was very nearly the same in both areas in 1940, grew more rapidly in the TVA counties. The same pattern existed for the percent of the population employed. The level of private

Table 7. Results of the analysis of variance between TVA and non-TVA groups in the commute category of counties for per capita income, percent of the population employed, manufacturing capital per capita, median school years completed, and percent of employment in agriculture

	1940	1950	1960	1970
Per capita income (current dollars)				
Estimated mean of non-TVA	217.55	685.81	1,145.96	2,131.64
Effect of TVA	-59.31**	-94.97**	-123.42**	62.21
Percent of the population employed				
Estimated mean of non-TVA	32.14	33.68	34.64	35.42
Effect of TVA	-1.51	-2.38**	-3.03	-.31
Manufacturing capital per capita (current dollars)				
Estimated mean of non-TVA	210.04	574.74	1,334.95	2,872.36
Effect of TVA	-30.77	-80.28	-.379	502.70**
Percent of the population which has completed high school or median school years completed[a]				
Estimated mean of non-TVA	13.44	7.52	8.22	9.46
Effect of TVA	-1.37**	.07	.00	-.27*
Percent of employment in agriculture				
Estimated mean of non-TVA	51.25	36.99	20.24	9.13
Effect of TVA	2.02	5.04*	1.79	.00

[a]Due to inavailability of data, percent of population 25 and over was used as a measure of educational achievement in 1940.

*Difference in the two groups significant at the .05 level.

**Difference in the two groups significant at the .01 level.

manufacturing capital per capita was higher in the TVA counties throughout the study period and was significantly higher (at the .01 level) in both 1960 and 1970. This could be attributable to the attractiveness of this area to manufacturing in general or to an industrial mix in the TVA area which was more capital intensive. The relative shift away from agricultural employment was apparently more rapid between 1950 and 1970 in the TVA area than in the non-TVA area. In 1950 the percent of employment in agriculture was

higher in the TVA counties (not significant), but by 1970 it was significantly lower in these counties.

The data on Table 8, therefore, lead to the hypothesis that the impact of a unified water resource development program in the hinterland counties was upon the ability of the area to attract manufacturing capital and make employment available outside of agriculture.

EVALUATION AND DISCUSSION

Many factors interact over time to cause change in areas such as those analyzed in this study. The models used in the study were

Table 8. Results of the analysis of variance between TVA and non-TVA groups in the hinterland category of counties for per capita income, percent of the population employed, manufacturing capital per capita, median school years completed, and percent of employment in agriculture

	1940	1950	1960	1970
Per capita income (current dollars)				
Estimated mean of non-TVA	163.71	544.44	964.03	1,912.30
Effect of TVA	.08	37.53	48.23	256.24**
Percent of the population employed				
Estimated mean of non-TVA	29.44	30.81	29.18	31.46
Effect of TVA	-1.00	.79	1.98*	2.67**
Manufacturing capital per capita (current dollars)				
Estimated mean of non-TVA	101.26	343.77	808.36	1,895.83
Effect of TVA	45.26	49.37	278.24**	1,119.28**
Percent of the population which has completed high school or median school years completed[a]				
Estimated mean of non-TVA	10.84	7.20	7.89	8.94
Effect of TVA	1.44*	.64**	.45**	.41*
Percent of employment in agriculture				
Estimated mean of non-TVA	58.45	43.46	25.04	13.09
Effect of TVA	-.75	2.14	-.45	-3.89**

[a]Due to inavailability of data, percent of population 25 and over was used as a measure of educational achievement in 1940.

*Difference in the two groups significant at the .05 level.

**Difference in the two groups significant at the .01 level.

designed to isolate as much of the impact of a unified water resource development program as possible but such an aggregative model is not completely efficient in this task. On the other hand, data limitations prohibit the use of more refined models. The results can, however, furnish valuable insights which are useful in assessing the impact of publicly-financed resource development programs.

Location of Impact

The analysis of the SMSA, commute, and hinterland counties supports the conclusion that the greatest impact of a unified water resource development program was in the counties most remote from urban population centers and least in the population centers themselves. Such a result is reasonable. SMSA counties are likely to have a number of growth-generating forces present so that the favorable impact of a water resource development program is not observable. On the other hand, in remote hinterland counties, growth-generating forces are minimal—indeed stagnating forces are likely to dominate. The impact of the types of programs undertaken by TVA are more likely to bear dividends in these areas. The impact in the hinterland counties may be the result of changes in the production function of the area because of changes in such things as transportation or power costs or they may be the result of changes in socioeconomic factors such as attitudes toward off-farm employment and willingness to encourage, or at least tolerate, change in community life such as that associated with industrialization.

The results of the analysis regarding locational differences in the impact of the TVA programs are important from a public policy point of view. They suggest that programs of public investment in water resources can influence the location of economic activity. However, additional research is needed to determine the specific link between the public investment programs and the impact realized.

Structural Impact

Some evidence of a divergence in the structure of the economies of the TVA area as opposed to the non-TVA area occurred in the counties in the commute group. In 1970 the paired test for statistical difference between coefficients was significant for two of the four variables (percent of employment in agriculture and education level). It must be noted, however, that this evidence is far from conclusive since in 1940, 1950, and 1960 statistically-significant differences in the paired coefficients were obtained for at least one of the variables

in the model. The research indicated that TVA and non-TVA counties had very similar structures in the SMSA and hinterland groups. Any conclusive differences that were indicated in 1940, 1950, and 1960 seem to have dissipated by 1970.

In summary, one must conclude that the research supports the hypothesis that little or no impact on the structure of the economies of the TVA area was associated with TVA investment. As the term "structure" was used in the study, this means that changes in the level of the variables would have about the same effect on per capita income in a TVA county as in a similarly-situated non-TVA county.

Manufacturing Capital Per Capita

Two comments about the manufacturing capita variable are useful in examining the results of the study. First, the variable was not "well behaved" in the structural model. Coefficients estimated for the variable were frequently negative, rarely statistically significant, and generally of little importance in explaining variation in the dependent variable. As was explained earlier, the data were constructed from various sources and apparently fell short of the ideal data one would wish to use in statistical analysis of the type carried out in the study. Nonetheless, they were considered the best available data on a county basis.

The second comment on the manufacturing capital per capita variable is more positive. It was the variable most consistently higher in the TVA area. It was significantly higher in TVA counties of all three groups in 1970 and in the hinterland and SMSA counties in 1960 as well. Even considering the limitations on the data, it is reasonable to assume that this was one factor explaining the favorable income movements in the commute and hinterland counties. In the SMSA counties the link between per capita income and manufacturing capital may be much less direct; thus, the income level was apparently not influenced by a higher level of manufacturing capital in these counties.

The Time of the Impact

From this study one finds that, although trends appear in the data over the entire period, significant effects of the TVA programs appeared much more strongly in the 1970 data than in 1950 and 1960. Indeed, if the same type of analysis had been performed without the benefit of the 1970 data, almost no conclusive evidence

of a favorable effect of TVA programs would have been demonstrated. (The only exceptions to this statement would be significantly higher levels of manufacturing capital per capita which existed in the hinterland and SMSA counties in the TVA group in 1960.) This leads to the conclusion that a time lag of substantial length occurs between introduction of a unified program of public investment in water resources and a significant impact of the programs on the economies of the region in which they operate. This conclusion supports the findings in previous work (3) which investigated the time lags between public investment in water resources and increased manufacturing employment.

APPENDIX

Construction of Variables

DATA USED in the study were collected from secondary sources. The unit of observation used throughout were counties. In the State of Virginia independent cities were combined with the county in which they were located, but the creation of the independent city of Galax from parts of Carroll and Grayson counties during the study period necessitated the combining of these two counties into a single unit of observation for each of the four observations (6). Grayson County is partially within the TVA Power Service area, but since the city of Galax did not receive power from TVA, the combined Carroll-Grayson county unit was included in the non-TVA classification.

Per Capita Income

Per capita income for a given year was equal to effective buying income as reported in *Sales Management Survey of Buying Power* (7, 8, 9, 10) divided by census year population. Income data for 1950, 1960, and 1970 were net effective buying income of households. This series is described as:

> personal income—wages, salaries, interest, dividends, profits, and property income, minus federal, state, and local taxes. It includes (1) net cash income plus (2) income in kind—payments in noncash goods and services, such as food and housing, and (3) imputed income—food consumed on the farm that produced it and imputed rent of owner-occupied housing . . . Effective Buying Income is generally equivalent to the Government's "disposable personal income." (10, p. xiii)

In 1940 gross effective buying income was reported. Gross effective buying income is generally equivalent to the disposable personal income. The difference in the two series is primarily attributable to taxes (8, p. 19). All income data were reported in current dollars and were not adjusted for price level.

Education

For 1950, 1960, and 1970, Census of Population data for median school years completed by the population age 25 and over was used to measure the level of education (22-41). This series was not reported in the 1940 Census of Population. For this reason, percent

of the population age 25 and over who completed high school was used to measure the level of education in 1940 (15-21).

Employment

Employment data were used in constructing the variables percent of population employed, percent of employment in agriculture, and private manufacturing capital per capita. All employment data were obtained from the U. S. Census of Population (15-42). The specific definitions of the employment variable used in the analysis are as follows:

Percent of the population employed	=Total employment ÷ population × 100
Percent of employment in agriculture	=Employment in Agriculture, Forestry, and Fisheries ÷ Total employment × 100

Inconsistencies in the collection and reporting of data for different census years occurred. The 1940, 1950, and 1960 censuses report employment of persons 14 years old and older for all categories while the beginning age for reporting all categories in the 1970 Census was 16. The 14- and 15-year-olds employed in 1970 were listed only as agricultural or nonagricultural employees.

A second discrepancy among the censuses occurred because employment categories were not consistent throughout the period. In all cases this consisted of combining categories in one census which were separate in others. Agriculture was combined with forestry and fisheries in the 1970 Census forcing the use of the broader category in all analyses. Likewise, subcategories of manufacturing employment changed from census to census. The categories of manufacturing listed on Table A-1 account for changes in census categories but also reflect categories for which capital investment data were available.

Capital Stock in Manufacturing

Estimates of capital stock in manufacturing industries were based upon the distribution of manufacturing employment among industries and the national average investment per production worker. Employment data were from the Census of Population. Capital data were reported in the *Economic Almanac 1967-68* (4) for 1939, 1949, and 1959. Data for 1969 were reported in "Capital Invested in Manufacturing" (2).

The specific definition of capital in manufacturing for county i in year j is:

$$K_{ij} = \sum_{k=1}^{11} M_{ijk} C_{jk}$$

where:

K_{ij} = total capital in manufacturing for county i in year j
M_{ijk} = employment for year j in manufacturing category k in county i
C_{jk} = national average level of capital per production worker for year j in manufacturing category k
The values for C_{jk} are given on Table A-1.

Table A-1. Capital per production worker in various categories of manufacturing employment for 1940, 1950, 1960, and 1970

Type of industry[a]	1940	1950	1960	1970
Lumber and furniture products	4,465	4,565	9,512	18,215
Primary and fabricated metal products	7,892	8,974	18,118	21,275
Machinery except electrical	8,300	10,432	18,034	31,226
Electrical machinery	4,061	7,190	12,537	28,854
Motor vehicles and other transportation equipment	7,050	8,428	17,914	46,920
Stone, clay, and glass products	5,577	6,594	16,174	26,731
Food and beverages	6,505	9,837	18,485	37,429
Textiles and their products	2,106	4,483	6,789	11,658
Printing and publishing	6,281	8,279	12,945	25,738
Chemicals and allied products	15,758	20,737	36,291	67,651
Other miscellaneous manufacturing	5,048	14,666	27,890	34,924

[a]In cases where categories were combined, weighted averages were used to arrive at the overall figure.

Sources: National Industrial Conference Board, *The Economic Almanac 1967-68*. Ken Goldstein, "Capital Invested in Manufacturing," *Roadmaps of Industry*, February, 1972.

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