# THE LOCAL ECONOMIC EFFECTS OF LARGE DAM RESERVOIRS: U.S. EXPERIENCE, 1975-95

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**ABSTRACT:** Dam construction has been an important component of economic development initiatives in the United States. However, few comprehensive ex post empirical studies examine the effects of such projects on local employment and income. This paper employs quasi-experimental control group methods to examine the effects of large dam reservoirs on county income, earnings, population, and employment growth for dams opened in the U.S. during the period 1975-1984. This paper shows that large dam reservoirs have some statistically significant positive effects and tend to stimulate growth. There is considerable variation, however, with dams constructed for flood control purposes and dams located further away from markets and large cities having less of an effect.

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## 1.0 Introduction

New dam construction has played an important role in U.S. efforts to develop water resources during this century. Although these projects often have multiple objectives, they are usually motivated by a desire to upgrade water resource management and improve economic efficiency. Whether or not a particular project is likely to contribute to these goals can be determined in advance by ex-ante evaluation studies, which attempt to estimate the degree to which a dam is a worthwhile public investment before it is built. Two things are notable about such studies in the U.S.: (1) the spatial focus is generally national rather than local, and (2) actual and imputed social costs and benefits rather than the potential to generate income or employment are usually used to assess projects.

This cost-benefit orientation, propelled by public finance evaluation methodologies whose use is required for most federal water projects, is unfortunate in one sense. Dams, like other types of infrastructure, are often sold to the public as regional or local economic remedies. They are purported to be investments with salutary effects on the income and employment of economically depressed regions. Cost-benefit analysis may show that a proposed dam is not too costly relative to its potential to improve the lives of people, for instance, by making it more convenient to travel or recreate or less expensive to ship goods, conserve topsoil, or provide water for drinking, irrigation, or power plant cooling. Yet for many lagging communities, generating income and employment is a more immediate issue.

To date, however, the link between dams and local jobs and income is not well understood and has never been carefully measured. Therefore, the objectives of this paper are to outline possible links between dams and economic growth, review previous studies, and measure systematically the actual effects of dam reservoirs on local economic growth and development. More specifically, this study examines selected dams constructed during the period 1975-1984 and provides a detailed analysis of their effects on county income, employment, population, and earnings. This paper uses a quasi-experimental control group method (Isserman and Merrifield 1982, 1987; Isserman and Beaumont 1989) that has been used to assess the effects of various public and private investments, including coal-fired power generation projects (Calzonetti et al. 1989), nuclear weapon facilities (Greenberg et al. 1998), coal mining facilities (Isserman and Merrifield 1987), state recreational parks (Isserman and Merrifield 1982), military base closures (Isserman, Stenberg, and Sorenson Forthcoming), gambling casinos (Rephann et al. 1997), the Appalachian Regional Commission (Isserman and Rephann 1995), and highways (Rephann and Isserman 1994).

This paper is divided into several sections. The next section examines the role of water resource development in the United States and reviews studies of the relationship between dams and regional economic growth. Section three introduces and explains the quasi-experimental control group method for assessing the local economic effects of dam investment. Section four describes the data used in this analysis. Section five presents the empirical results.

## 2.0 Economic Effects of U.S. Dam Reservoirs

Water resource agencies in the United States have been established primarily to make navigation improvements, control floods, improve irrigation, generate power, and promote economic growth and development. The first U.S. agency to undertake dam construction was the Army Corps of Engineers (CE), which was given the responsibility to develop inland waterways in 1824. This federal scope was expanded to irrigation with the 1877 Desert Land Act, flood control with the creation of the Mississippi River Commission in 1879, and power generation shortly thereafter (Viessman and Welty 1985). The next major spate of legislation occurred early in the 20th century, when reclamation, conservation, and regional economic development were added to the list of federal responsibilities. Numerous agencies, including the Bureau of Reclamation (USBR), the Tennessee Valley Authority (TVA) (1933), and the Soil Conservation Service (SCS)

(1936) were created during this time. Smaller agencies also have been involved in dam planning and construction.

Through these agencies, billions of dollars and a vast amount of nonrenewable natural resources have been expended in the development of water resources via dam projects. During the 1960s and 1970s, the average investment in water resource projects by the Army Corps of Engineers alone was more than 2 billion dollars per year (U.S. Army Corps of Engineers 1979). In addition to the financial costs, dam construction has ecological, economic and social costs. Although engineers, economists, and planners have applied a variety of research methods to attempt to assess these effects, social benefit-cost analysis remains the most popular analytical technique. Indeed, benefit-cost analysis owes its continuing refinement and state of sophistication to the ample research funding made available for dam project evaluation (Musgrave and Musgrave 1980). According to benefit-cost logic, a project is justified from a public standpoint if its social benefits exceed its social costs.

The extent to which a project affects local employment and income growth has generally been ignored in benefit-cost analysis (Attanasi 1975; Cicchetti, Smith, and Carson 1975; Anderson, Miguel, and Lichty 1989). Benefits are generally calculated as the incremental national output created by the project. A project may have a positive impact on the nation and a negative impact on local output simultaneously. Yet, such a project is recommended if the improvements to national output exceed the expected costs. For instance, a waterway project may contribute to national output by reducing the cost of shipping bulky commodities such as grain, steel products, crude petroleum, and coal. This lower cost of delivering commodities affects both the selling and purchasing industries. This initial cost reduction will then create positive multiplier effects in industries throughout the nation. Meanwhile, the area where the dam resides may experience negative economic impacts because of the loss of developable land resources, loss of river recreational development opportunities, or even competitive disadvantages created for local industry caused by the new transportation configuration. In this case, the project may hurt the host area, which is often a rural or lagging area, in the interest of national economic development.

Only a handful of peer reviewed studies examine the effect of U.S. water resource development (including dams) on regional or local income or employment growth. The consensus does not favor using large dam reservoirs as economic development tools. In most empirical studies, increasing water supply has been found to be a poor mechanism for stimulating local economic growth (Bower 1964; Howe 1968; Cox, Grover, and Seskin 1971; Eckstein 1971; and Hussein 1981). Fairly typical is the conclusion of Cox, Grover, and Seskin, who examined large multi-purpose water projects in 61 northeastern counties during the 1948-1958 period and concluded "[I]t is dubious whether water resource projects serve as a stimulus to economic growth for the strictly rural counties . . . [W]ater resource developments are likely to be poor tools for accelerating economic growth of small rural regions . . ."

In the few instances where dams have been found to have an effect on regional employment growth, the effect is more likely to be connected with recreational uses of the resultant reservoir rather than effects on transportation, utility, or water costs that might potentially lure water using industries to the region (Aleseyed and Rephann 1994; Gjesdahl and Drake 1979). Water is often an unimportant factor in industrial location decisions; it usually constitutes a small proportion of production costs and other inputs can readily be substituted for it (Howe 1968). Even when recreation is stimulated, it is unlikely to stimulate regional growth and development (Gjesdahl and Drake 1979).

These findings could result from research design considerations. One major concern is the nature of the dam itself. Dams and their resultant reservoirs vary considerably. As mentioned above, they serve a variety of uses, including hydroelectric generation, irrigation, water supply, flood control, navigation, and recreation. Many dams have secondary and tertiary purposes. For instance, a dam built for the primary purpose of generating electricity may also be used to irrigate nearby areas, while at the same time providing recreational opportunities. Thus, different types of dams (and reservoirs) would be expected to affect different sectors of the regional economy. For instance, hydroelectric dams might have a direct link (albeit small) with public utility employment, a navigation dam might influence trade and transportation, an irrigation dam might increase employment in agriculture, a water supply dam might influence industry and residential location; and a recreation dam might stimulate residential location and tourism. Dams also vary in their physical dimensions, such as height and width and volume of reservoir. Holding all else constant, dams with large reservoirs might have greater construction and post-construction effects than smaller dams.

Regional characteristics are also important. The ultimate economic effect of any given dam is, to a certain extent, shaped by regional surroundings--both physical and socioeconomic. Most dams are built in rural regions. Yet, these places have limited potential to attract additional industry because of poor economic development facilitators, e.g., weak interindustry linkages, poor infrastructure, and a lower quality of human resources (Howe 1968; Cox, Grover, and Seskin 1971; Garrison and Paulson 1972; Attanasi 1975; Evans and Associates 1980). Rural regions with few climate or topological amenities, restrictive land-use regulations, and poor access to lucrative urban markets are especially limited for recreational development. Regional water needs may also determine the economic effects of dams. Some regions are blessed with ample water resources already, particularly regions in the humid continental and humid subtropical areas of the eastern United States (where dams often serve to control floods). However, in the arid west and plains states, limited water supply may stymie residential, industrial, and agricultural development, making a reservoir more important for employment generation.

Other research design concerns are the time period of analysis and degree of effort expended in controlling for confounding influences on regional growth. Most studies allow only a few years to elapse before they attempt to assess the economic impact of the new construction (Evans and Associates 1980). Yet, Attanasi (1975) finds that economic effects are not evident until much later. Other studies make only a weak attempt to control for various other non-dam related influences on regional growth (Aleseyed 1995), so they may produce biased estimates of the effects of new dam construction.

## 3.0 Quasi-Experimental Control Group Method

### 3.1 Basic Vocabulary

Quasi-experimental designs are appropriate and useful when a researcher wants to make causal inferences but experimental control is not feasible. Experimental control requires the random assignment of subjects to treated and untreated groups, which is not feasible for large-scale infrastructure projects like dams. The design used in this study is a specific kind of quasi-experimental method. It combines the interrupted time series design and the nonequivalent control group design (Campbell and Stanley 1966). The strength of the former method is its attention to history as a plausible explanation for the observed effects. The strength of the latter is its attention to cross-sectional factors. These designs are combined by carefully selecting a quasi-experimental control group during a calibration period and examining treated subjects and their control groups for differences in performance during two periods, the pre-treatment and treatment periods.

Quasi-experimental control group methods are implemented for geographical analysis by choosing places (henceforth assumed to be U.S. counties) for use as benchmarks to measure the effects of policies. Control group suitability is formally evaluated using a pre-test which compares the performance of the carefully selected control group to the treated counties during a period before the policy treatment is administered. If this test is passed, a post-test is conducted to measure the effect of the policy treatment during the treatment period. The control group selection process, pre-test, and post-test are explained in the following section.

### 3.2 Control Group Selection and Statistical Testing

To identify a suitable control group for an individual treated county from a population of n counties, two sets of information are used. Selection characteristics are used to identify the control group; they are mainly socio-economic variables measured well in advance of the dam construction. They will be discussed in section 4.2. Growth rates are used to evaluate the adequacy of the selected control group in the pre-test and to measure the economic effect of the policy in the post-test. Income, earnings, population, and employment growth rates are used here, with the economic variables available at the division level (e.g., manufacturing or services). The growth rates are discussed further in section 5.0.

Three techniques are combined to select a control county for each treated county. They are sequential caliper matching, nearest available matching, and optimal matching. Sequential calipers eliminate counties from the set of potential control counties (termed the control reservoir) if they do not meet specified conditions. For instance, a county cannot itself contain a large dam reservoir and serve in a control group to study the effects of large dam reservoirs. Nearest available matching uses a distance metric to allow dissimilarity on one variable to be traded-off for better fit on another variable. Counties that were not removed from the control reservoir by the calipers are ranked according to their similarity with a given treated county using Mahalanobis distance to measure similarity.[1] Under nearest available matching, the first treated county is assigned its nearest match, the second treated county is assigned its nearest match after the first county's match is eliminated from consideration, and so on. Thus, the order in which the treated counties are matched can affect the outcome. Optimal matching, on the other hand, selects the unique set of control counties that minimizes the sum of the distances from their matches for the whole treated group (Rosenbaum 1989). It makes the control group as much like the treated group as possible.

The hypothesis that the control group counties reflect what happened to the treatment county prior to the treatment can be tested by comparing mean growth rate differences during the pre-treatment period. This difference of means test is based on a student's t distribution. Ideally, the mean of the differences between the growth rates of each treated county and its twin is not significantly different from zero before the dam is constructed. If the treated counties grew slower than their twins, this selection bias means that the treatment effects will be underestimated. If the treated counties grew faster, the control group will not be useful in measuring positive treatment effects. (See Isserman and Rephann 1995 for more detail.) The post-test compares growth rate differences after dam construction has begun. If the dams stimulate local growth, the control group study should find no significant differences in the pre-test period before construction and significant differences beginning sometime after construction commences (or in the case of selection bias, negative differences followed by positive or no differences).

## 4. Data

### 4.1 Study Units and Economic Data

The spatial units are approximately 3,100 counties in the United States. Several considerations motivate the use of counties. First, socioeconomic data are more readily available for counties than other small government units. The primary source of data is the Bureau of Economic Analysis' (BEA) Regional Economic Information System. Second, most dams create sizable reservoirs that fit more easily into county boundaries than smaller jurisdictions such as U.S. Census Minor Civil Divisions or Census Tracts. Finally, counties are small enough to allow substantial heterogeneity among the types of study units. For instance, using county units allows rural areas to be distinguished from more urbanized ones.

Two separate databases from the BEA are used. The older one is available for the years 1950, 1959, 1962, and 1965-1984 and contains population, personal income, and earnings by industry. The newer one covers the period 1969-95 and contains employment by industry as well as the previous variables. During the 1980s, the BEA revised its regional income accounting methodologies without updating the older series, so the two series are not compatible and cannot be combined into longer time series. BEA calculates total income by subtracting social insurance payments from total earnings and adding residential adjustment income, dividends, interest, and rent income, and transfer payments to total earnings. The residential adjustment is income attributed to commuter flows. It is the difference between the earnings of people who live in the county but work elsewhere (i.e., income "injected" into the county) and earnings of people who work in the county but live elsewhere (i.e., income that "leaks" out of the county). Earnings include proprietors' income as well as wages and salaries.

**4.2 Selection Variables**

Four types of selection variables are used here: (1) a variable indicating the presence of a policy treatment, i.e., the construction of a large dam reservoir, (2) a variable indicating whether a county is within 60 miles of another county, (3) a data suppression indicator, and (4) an extensive list of variables based on regional economic theory (see table 1).

The first three types are calipers. As described earlier, to be included as a potential control county, a county must meet the condition described by the caliper. The first caliper guarantees that a control county will not have a large dam within its boundaries. This dam treatment caliper removes those counties that have dams with reservoir capacities larger than 50,000 acre-feet, a size designated "large" by the Geological Survey (U.S. Department of the Interior). The second caliper removes counties in close proximity to the treated county in order to ensure spatial independence when measuring effects (Isserman and Merrifield 1987). The third caliper eliminates counties with missing data. It is needed because the Mahalanobis metric cannot be computed if one or more counties have missing data for any of the selection variables.

The final type of variable reflects determinants of regional economic growth, including industrial structure, market demand, and prior growth (Rephann and Isserman 1994; Rephann 1993). The income shares of farming, manufacturing, retail trade, and federal government (military and civilian) measure industrial structure. (Data suppression is not a serious problem for these industries.) Per-capita personal income, population potential, and distance to a city with 100,000 or more residents are measures of regional market demand and location. County population measures urbanization. The growth rates of personal income and population measure county growth before the pre-test period and serve much like lagged variables in a regression model.

### 4.3 Dam Characteristics

Information about counties and their dams is used to select the treated counties. Among the characteristics are the dam's capacity, its primary usage, its location, and its construction year. Capacity refers to a dam's maximum reservoir storage in acre-feet. According to the Geological Survey, a maximum storage in excess of 5,000 acre-feet constitutes a normal capacity dam. Dams with normal capacity are subdivided into three size classes: small (capacity between 5,000 and 25,000 acre-feet), medium (capacity between 25,000 and 50,000 acre-feet), and large (capacity of more than 50,000 acre-feet).

The National Inventory of Dams Data (Federal Emergency Management Agency 1996) lists 75,187 dams in the United States in 1995-96 (inclusive of Alaska and Hawaii). Of this total, 70,353 have a capacity less than 5,000 acre-feet. Of the remainder, 2,715 are small, 587 are medium-sized, and 1,532 are large. Large dams are found in nearly every state, with major concentrations in northern California, Washington, northern Minnesota, northeastern Texas, and the Tennessee Valley. The highest rates of dam completion were achieved during Roosevelt's New Deal and the post-war years (figure 1). Dam completion dropped off dramatically during and immediately following World War II because of resources being diverted into the war effort. Another descent, during the late 1970s and 1980s, may signal the end of an era of large dam construction and the beginning of a focus on dam maintenance. As figure 2 shows, large dam reservoirs are associated with a variety of functions, but the most common primary purposes listed in the National Inventory are hydroelectric, flood control, irrigation, and water supply. Less than one-quarter of all large dam reservoirs result from dams constructed for navigation, recreation, or other purposes (e.g., debris control, fire protection, or fish and wildlife).

### 4.4 The Study Dams

Selecting which of the 75,000 dams to study involves several restrictions. First, large dams are analyzed because one might expect them to have the largest measurable impacts and because so many counties have smaller dams that too few counties would be available to serve as control counties to study smaller dams. Second, dam construction must be completed within the period 1975 to 1984. This time period provides a large number of dam-treated counties, avoids income data discontinuities, prevents the onset of construction from contaminating the pre-test, and leaves enough years for post-test analysis.[2] Third, neither study nor control counties can have large dams constructed earlier because, if they did, the results would not be an accurate measure of the effects of creating a large dam reservoir. Finally, dams in counties with missing data for four or more income categories are dropped in order to avoid an excessive amount of data suppression which would limit post-test inferences. These criteria produce a group of 48 dams (the complete list is available from the authors). The primary purposes of the dams are flood control (19), water supply (6), hydroelectric (4), irrigation (4), navigation (3), recreation (1), and other (11).

## 5.0 Results

The older BEA income series is used to select the control group and analyze its validity. Since the annual income data series is not continuous until 1965, the period 1959-62 is used for control group selection, the year 1962 as the base year for pre-test purposes, and the period 1965-69 for pre-tests. The post-treatment period is covered entirely by the newer series. Given a maximum of five years for construction and 1975 as the first completion date, 1970 is the first year in which any construction effect might be observed. Therefore, 1969 is the base year for calculating treatment effects. The growth rate differences between a treated county and its control are cumulative; hence, the 1995 difference is calculated from 1969 to 1995. Isserman and Merrifield (1982) contains a derivation of this cumulative rate.

### 5.1 Control Group Diagnostics

A series of t-tests found no significant differences in the mean values of the treated counties and the control counties for the twelve selection covariates. The mean values are shown in table 2 for the treated counties, the matched control counties, and all 3,022 counties. One characteristic of the matching process is noteworthy. It does not assure that the matched counties' mean is closer to the treated counties' mean on every variable when compared to all counties. Here the matched counties are more like the treated counties for nine of the twelve covariates. In three cases, percentage manufacturing, percentage residence adjustment, and population growth rate, the all county mean is closer to the treated county mean. This result can be attributed to the Mahalanobis distance measure. When making matches, it trades off more similarity on one variable for less in another. It scales and weights the variables by the variance-covariance matrix derived from the control reservoir and seeks to preserve the original variability in the control group. The Mahalanobis metric is "forgiving" on those high-variance variables for which it is difficult to find close observations, and, as a consequence, these high-variance variables are less likely to have close control group fits. Indeed, all three variables for which the Mahalanobis metric does not produce a closer control group are among the four variables of the twelve with the highest ratios of standard deviation to mean.

The years 1965-1969 form the basis for evaluating whether or not the control group performs adequately. Ideally, there would be no significant differences between the growth rates of the treated counties and their twins during this pre-treatment period. The pre-test results are shown in Table 3. There are a few positive and statistically significant differences from zero (using a=.10). The small sector, agricultural services, forestry, and fisheries, grew faster in the treated counties for the entire pre-treatment period. Likewise, dividends, interest, and rent grew faster over 1962-1965, and finance, insurance, and real estate grew faster over 1962-1967. The agricultural services result means that any findings of a positive effect during the treatment period should be disregarded. Basically, it failed the pre-test and is not well calibrated for post-test purposes. However, the other positive significant results were not sustained and are possibly connected to random events rather than indicators of any systematic variation. There is one statistically significant negative difference, federal government in 1962-65. Here the treated counties grew more slowly than their matches during the pretreatment period, so any positive effect measured during the treatment period would be an underestimate. For all the major sectors and variables, however, there are no significant differences, so the control group is satisfactory.

### 5.2 Mean Treatment Effects

The 48 treated counties outgrew their twins in several sectors during the treatment period, 1970-95 (tables that show the results by sector are available from the authors). Aggregate growth indicators, such as total earnings and wage and salary income, have statistically significant, positive differences by the final three years of the study period. The presence of a large construction bulge, beginning in the mid-1970s (see figure 3), is strong evidence of dam construction and perhaps related construction such as infrastructure and homes. Federal government effects during several construction years (statistically significant for 1971-77) may reflect the presence of the Army Corps of Engineers in dam engineering and construction. Manufacturing employment and earnings also are stimulated during many intermediate construction period years, suggesting possible backward linkages between dam construction and dam-related mining and manufacturing activities such as stone mining and quarrying, asphalt paving, brick and structural clay manufacture, and cement and concrete manufacture. Yet persistence of the manufacturing growth differentials beyond the construction period suggests that the effects on manufacturing might be broader based, in contradiction to arguments that water supply does not affect manufacturing location.

As noted earlier, the effects of dams may be may be influenced by their characteristics. Navigation dams facilitate waterway transportation, power generation dams create some public utility employment, irrigation dams result in greater agricultural productivity and output, and recreation dams influence sectors related to tourism, such as services and retail trade. When these results are averaged, the specific effects of certain kinds of dams might be obscured by the overall averages.

The importance of the nature and purpose of the dam is underscored here with an empirical result: Whereas the 48 treated counties outgrew their twins by 26 percentage points in total employment between 1969 and 1995, the 29 treated counties whose dams had a primary purpose other than flood control outgrew their twins by 60 percentage points. Thus, the local economic effects of dams other than flood control dams might be larger than the findings reported above. In order to investigate this possibility further, the full set of treatment tests was replicated for the 29 counties. Statistically significant sectors are highlighted in figures 4 and 5 (tables of the results are available from the authors).

The results for this subgroup reveal a broader array of sectoral impacts that persist for a longer duration. As before, total earnings, wage and salary income, and manufacturing earnings show statistically significant differences, but population, dividends, interest, and rent income, transfer payments income, farm earnings, transportation, communication, and public utilities earnings, wholesale trade earnings, federal, civilian government earnings, and state and local government earnings do also. Furthermore, several employment sectors, finance, insurance, and real estate, and federal, civilian government, become statistically significant. Not all of these impacts commence with the earliest dam reservoir opening date; for instance, total personal income is first statistically significant in 1974, dividends, interest, and rent income becomes statistically significant in 1970, farm earnings in 1972, wholesale trade earnings in 1971, and federal, civilian government in 1971.

Sectoral effects as the first dams were functional are of greater interest. Statistically significant manufacturing earnings and employment effects, as described earlier, begin in 1975 and persist for the post-construction period. Services (beginning in 1975) and retail trade (starting in 1976) are statistically significant until 1983, suggesting that these effects may be linked to dam construction and secondary dam construction effects rather than residential, industrial, or tourism effects stemming from the dam reservoirs. Population begins to become statistically significant in 1983, followed by finance, insurance, and real estate (FIRE) employment in 1987, suggesting that dam reservoir counties are more attractive residential sites and have more vigorous real estate activity. Transportation, communication, and public utilities (TCPU) sector earnings begin to grown significantly faster by 1986, maybe related to the hydroelectric or water supply dams present in the group, but quite possibly reflecting the provision of services to the other growing activities. Finally, state and local government earnings also had grown significantly faster in the dam treated counties by the final impact year; perhaps the reservoirs become state parks or the additional real estate activity and commerce generated new tax revenue which led to more local government.

The relative size of the sectors should not be ignored when evaluating the economic importance of the results. The manufacturing result is the most impressive in an absolute sense, since the industry makes up a large portion (i.e., on average, twenty-five percent of county earnings in the base period) of the county economies, followed by state and local government (on average, eleven percent of total earnings). While the percentage points impact estimates for transportation and public utilities and finance, insurance, and real estate are impressive in a relative sense, they were comparatively small components (i.e., each contributed less than five percent of county earnings and employment in 1962) of the treated county economies. Hence, they contribute much less to the aggregate effect of dam reservoirs.

**5.3 Variations among Effects**

Although the mean treatment effects are positive and significant, there is a danger in generalizing from means alone. The economic development practitioner and residents of a potential host county for a dam have an immediate, specific question: Will a proposed dam produce economic growth in their county? The numbers behind the means do not produce comforting answers across the board. Of the 48 treated counties, 27 grew faster than their matches and 21 did not over the period 1969-1995. Excluding the flood control counties, 18 grew faster than their matches and 11 did not. The balance of this section is an exploration of the empirical results aimed at learning more about when dams are more likely to stimulate growth.

The purpose and the nature of the dam have already been recognized as important determinants of its effect. Characteristics of the region may also be important. Regional economists have long argued that physical infrastructure investments are more likely to lead to production improvements when they are built in more urbanized regions or areas with prior development potential (Hansen 1965; Rowley, Grigg, and Rossi 1990). The dam completion date may also explain variations in the findings. A dam completed toward the end of the construction period (e.g., 1984), would have less time to affect county growth and development than one built much earlier (e.g., 1975).

The numbers of dams is too small to stratify the sample and examine different kinds of dams and different regions separately, but these hypotheses can be evaluated by the regression equation presented in table 4. The dependent variable is the difference in total employment growth between a treated county and its match from 1969 to 1995. PURP is a dummy variable indicating whether or not a dam's primary function is flood control. STOR represents the volume of the dam reservoir, measured in thousands of acres-feet. START is the number of years since the dam was completed. CITY100 is the distance from the treated county to a city with at least 100,000 residents in 1980, measured in miles. LPTPP is the natural log of the treated county's population potential within a 60-mile radius (or about 100 kilometers) in 1985. WATAREA is the percentage of the county's total area in 1990 that is covered by water. MAHAL is the Mahalanobis distance, the measure of similarity between the treated county and its county match.

The regression results support three conclusions. First, the spatial context of the dam matters. The positive coefficient for LPTPP indicates that counties with more people in the nearby vicinity are more likely to experience growth as a result of the dam. The negative coefficient for CITY100 makes the same general point, the nearer a larger city, the more likely the dam will generate growth. Note that the control group selection process matched the treated and control counties using these criteria; the regression results suggest that, among the matched pairs, those nearer to population concentrations had greater growth rate differences. Second, the purpose of the dam matters. A flood control dam, which after all is constructed and managed to reduce damage downstream from the host county, is less likely to produce a positive effect in the host county. Third, neither reservoir size, timing of construction, water availability, nor the closeness of the match between treated county and its twin produce any systematic variation in the findings. There are insignificant coefficients for STOR, START, WATAREA, and MAHAL. Yet they are all of the expected sign. The more years since construction, the more positive the effect. The larger water storage, the more positive the effect, but the more other surface water available, the smaller the effect. Finally, the less successful the match between the treated county and its twin, the greater the difference in their growth rates. Altogether these variables explain 24 percent of the variation in the growth rate differences, an impressive result for a dependent variable that is a cross-section of the difference in growth rates.

## 6.0 Summary and Conclusion

When dam construction feasibility is judged by standard social benefit-cost evaluation considerations, the effects of large dam reservoirs on local employment and income are often ignored. This oversight is unfortunate because economic development is often the primary local goal in supporting dam construction. This paper fills in one piece of the rural development picture. It provides an analysis of the effects of large dams on county income and earnings growth. Using quasi-experimental control group methods adapted for geographical analysis, it shows that large dam reservoirs tend to have positive effects on the counties in which they are located, but there is much variation within the results. Key determinants of a dam’s effect appear to be the purpose of the dam and its spatial context. Dams constructed for flood control purposes tend to have less of a stimulating effect, and areas further from cities and with fewer people within 100 kilometers miles fare less well.

**Endnotes**

[1] The Mahalanobis distance is represented as $d^2(\mathbf{X}_T,\mathbf{X}_i) = (\mathbf{X}_T - \mathbf{X}_i)^T \mathbf{S}^{-1} (\mathbf{X}_T - \mathbf{X}_i)$ where $(\mathbf{X}_T - \mathbf{X}_i)$ is the difference between the vector of selection variables for the treated county and county i and $\mathbf{S}$ is the sample variance-covariance matrix of the counties in the control reservoir.

[2] Because of the lack of data on the beginning of construction, it is assumed that the maximum time for dam construction is five years. This decision was made on the basis of several telephone interviews with major dam operators, who stated that dam construction is normally completed within 5 years. Therefore, all (or almost all) of the study dams should have began construction after 1969, which is used as the base year in treatment period calculations.

**References**

Aleseyed, M. 1995. A study of economic impacts of large dams in rural economies using quasi-experimental control group methods. Ph.D dissertation, West Virginia University.

Aleseyed, M., and T. J. Rephann. 1994. The effects of large dams on small economies. Morgantown, WV: Regional Research Institute, Working Paper #9403.

Anderson, C. L., L. G. Miguel, and R. W. Lichty. 1989. Water analysis: A systems approach incorporating linear programming. Growth and Change 20, 1: 80-89.

Antle, L. G. 1975. An overview of the impact study of the McClellan-Kerr multiple purpose Arkansas River system. IWR Research Report 75-R3.

Attanasi, E. 1975. Regional impact of water resources investment in a development area. Water Resources Bul*letin* 11, 1: 69-76.

Badger, D. D., and S. G. Cabbiness. 1980. Economic impact of recreation business in counties along the McClellan-Kerr Arkansas River navigation system. IWR Contract Report 80-C-5.

Bower, B. T. 1964. The location decision of industry and its relationship to water. Paper presented at the Conference of the Committee on the Economics of Water Resources Developments, San Francisco.

Calzonetti, F., T. Allison, M. A. Choudhry, G. G. Sayre, and T. S. Witt. 1989. Power from the Appalachians: A solution to the Northeast's electricity problems? New York: Greenwood Press.

Campbell, D. T., and J. C. Stanley. 1966. Experimental and quasi-experimental designs for research. Chicago: Rand-McNally.

Cicchetti, C. J., V. K. Smith, and J. Carson. 1975. An economic analysis of water resource investments and regional economic growth. Water Resources Research 11, 1.

Clark, Jr., M. W., and D. P. Robinson. 1987. Economic impacts of transportation improvements. Presented at the 35th Annual Meetings of the Southern Regional Science Association, 26-28 March 1987, Atlanta, GA.

Cook, T. D. and D. T. Campbell. 1979. Quasi-experimentation, design and analysis issues for field setting. Boston: Houghton Mifflin.

Cox, P. T., W. Grover, and B. Seskin. 1971. Effect of water resource investment on economic growth. Water Resource Journal. 8, 1: 32-39.

Eckstein, O. 1971. Water resource development: The economics of projects evaluation. Cambridge: Harvard University Press.

Evans, R. E. and Associates. 1980. A study of the impact of the Hugo Reservoir on Choctaw and Pushmataha Counties: A view four years after completion. Submitted to U.S. Corps of Army Engineers, IWR.VA Research Report 80-R1.

Federal Emergency Management Agency. 1996. National inventory of dams data. Washington, DC.

Garrison, C. B., and A. S. Paulson. 1972. Effect of water availability on manufacturing employment in the Tennessee Valley region. Water Resources Research 8, 2: 301-316.

Gjesdahl, D., and W. Drake, Jr. 1979. Impact of dam and lake construction on rural economics. Fort Belvoir, VA: U.S. Army Corps of Engineers, Institute for Water Resources. IWR Research Report 79-R4.

Greenburg, E., C. L. Leven, J. T. Little, and R. P. Parks. 1980. Estimating economic development impacts: An alternative approach. Institute for Urban and Regional Studies, Washington University, Contract Report 80-C3.

Greenberg, M., A. Isserman, D. Krueckenberg, K. Lowrie, H. Mayer, D. Simon, and D. Sorenson. 1998. Socioeconomic impacts of nuclear weapons facilities: A local scale analysis of Savannah River, 1950 to 1993. Applied Geography. Forthcoming

Hansen, N. M. 1965. Unbalanced growth and regional development. Western Economic Journal 4: 3-14.

Haveman, R. H. 1965. Water resource investment and the public investment. Nashville: Vanderbilt University Press.

Howe, C. W. 1968. Water and regional growth in the United States 1950-1960. Southern Economic Journal 34: 477-499.

Hussein, F. M. 1981. Dams, people and development: The Aswan High Dam case. New York: Pergamon Press.

Isserman, A., and P. Beaumont. 1989. Quasi-experimental control group methods for the evaluation of regional economic development policy. Socio-Economic Planning Sciences 23: 39-53.

Isserman, A., and J. Merrifield. 1982. The use of control groups in evaluating regional economic policy. Regional Science and Urban Economics 12: 45-58.

Isserman, A., and J. Merrifield. 1987. Quasi-experimental control group methods for regional analysis: An application to an energy boomtown and growth pole theory. Economic Geography 63: 3-19.

Isserman, A., and T. Rephann. 1995. The economic effects of the Appalachian Regional Commission: An empirical assessment of 27 years of regional planning experience. Journal of the American Planning Association 61: 345-364.

Isserman, A., P. Stenberg, and D. Sorenson. Forthcoming. The recovery of rural economies from military base closures: Control group analysis of two decades of experience. Economic Development Quarterly.

Knetsch, J. L. 1964. The influence of reservoir projects on land values. Journal of Farm Economics 46, 1.

Musgrave, R. A., and P. B. Musgrave. 1980. Public finance in theory and practice. New York: McGraw-Hill.

Rephann, T. J. 1993. A study of the relationship between highways and regional economic growth and development using quasi-experimental control group methods. Ph.D dissertation, West Virginia University.

Rephann, T. J., and A. Isserman. 1994. New highways as economic development tools: An evaluation using quasi-experimental matching methods. Regional Science and Urban Economics 24, 6: 723-751.

Rephann, T. J., M. Dalton, A. Stair, and A. Isserman. 1997. Casino gambling as an economic development strategy. Tourism Economics 3, 2: 161-183.

Rosenbaum, P. R. 1989. Optimal matching for observational studies. Journal of the American Statistical Association 84: 1024-32.

Rowley, T. D., N. S. Grigg, and C. V. Rossi. 1990. Water and wastewater investment to promote economic development. In Infrastructure investment and economic development: Rural strategies for the 1990s. Washington, DC: U.S. Department of Agriculture, Agriculture and Rural Economy Division. Staff Report No. AGES 9069.

U. S. Army Corps of Engineers, Missouri River Division. 1979. Impact of dam and lake construction on rural economies. IWR Research Report 79-R4.

U. S. Department of Commerce, Bureau of Census. 1979. County and city data book consolidated file, county and city data, 1947-1977. Prepared by the Data User Services Division. Washington, DC.

U. S. Department of Commerce, Bureau of Census. 1980. Census of population and housing, 1980: master area reference file (MARF) 2. Prepared by the Data User Services Division. Washington, DC.

U. S. Department of Commerce, Bureau of Economic Analysis. 1997. Regional economic information system. Washington, DC.

Viessman, W., and C. Welty. 1985. Water management: Technology and Institutions. New York: Harper and Row Publishers.

**Table 1. Control group selection variables.**

| | |
|---|---|
| *Industrial Structure* | |
| **PFAR** | Farm earnings share of total personal income, 1962. |
| **PMFG** | Manufacturing earnings share of total personal income, 1962. |
| **PRTL** | Retail trade earnings share of total personal income, 1962. |
| **PFED** | Federal government earnings (civilian and military) share of total personal income, 1962. |
| *Population, demand, and spatial aspects* | |
| **LPOP** | Logarithm of population (base ten), 1962 |
| **LPTPP** | Logarithm of population potential for counties within 60 miles, 1962 |
| **CITY100** | Distance to a city of population 100,000 or greater, 1960 |
| **PRES** | Residential adjustment share of total personal income, 1962 |
| **PTSF** | Transfer income share of total personal income, 1962 |
| **PCI** | Per capita total personal income, 1962 |
| *Growth* | |
| **RTOT** | Total personal income growth rate, 1959-62 |
| **RPOP** | Population growth rate, 1959-62 |

**Table 2. Mean profile of study counties, matches, and all U.S. counties , 1962.**

| | *Treated* | *Matches* | *All Counties* |
|---|---|---|---|
| *Industrial Structure* | | | |
| **PFAR** | 12.1 | 10.6 | 14.8 |
| **PMFG** | 13.7 | 15.1 | 14.1 |
| **PRTL** | 9.2 | 9.1 | 8.8 |
| **PFED** | 3.0 | 2.6 | 4.4 |
| *Population, demand, and spatial aspects* | | | |
| **LPOP** | 2.40 | 2.44 | 2.32 |
| **LPTPP** | 4.64 | 4.67 | 4.58 |
| **CITY100** | 66.9 | 71.9 | 89.8 |
| **PRES** | 9.1 | 7.8 | 10.2 |
| **PTSF** | 11.4 | 11.5 | 10.9 |
| **PCI** | 1,784 | 1,800 | 1,758 |
| *Growth* | | | |
| **RTOT** | 14.5 | 12.5 | 16.8 |
| **RPOP** | 3.8 | 2.9 | 3.3 |
| Number | 48 | 48 | 3,022 |

**Table 3. Personal income and earnings pre-test results, percentage points difference.**

| Sector | 1965 | 1966 | 1967 | 1968 | 1969 |
|---|---|---|---|---|---|
| Total personal Income | 0.4 | -0.5 | 0.8 | 0.9 | 1.0 |
| Population | -2.1 | -1.6 | -1.6 | -0.5 | 0.2 |
| Earnings by place of work | -1.9 | -3.1 | -1.5 | 1.4 | 1.7 |
| Residence adjustment | 0.3 | 0.2 | 0.2 | -1.3 | -2.2 |
| | | | | | |
| Dividends, interest, and rent (DIR) | 4.1* | 4.0 | 3.0 | -0.7 | 0.5 |
| Transfer payments | 1.1 | 1.2 | 1.3 | 1.8 | 2.1 |
| Wages and salaries | -2.5 | -2.8 | -2.9 | 1.5 | 1.9 |
| Farm | 2.2 | -10.0 | -2.5 | -7.6 | -2.1 |
| Private earnings | -3.0 | -3.6 | -4.5 | 0.4 | 1.4 |
| Agricultural services, forestry, fishing, and other | 53.6* | 69.9* | 100.3* | 109.3* | 127.9* |
| Mining | -21.8 | -27.4 | -36.3 | -30.8 | -39.1 |
| Construction | -1.9 | -6.6 | -7.1 | 9.0 | 11.0 |
| Manufacturing | -12.3 | -18.3 | -20.0 | -8.4 | 14.1 |
| Transportation, communication, and public utilities (TCPU) | -5.5 | -6.6 | -8.0 | -8.3 | -5.3 |
| Wholesale trade | -1.9 | -2.6 | -2.8 | 5.3 | 9.0 |
| Retail trade | -0.1 | -0.5 | -1.7 | -2.0 | 0.1 |
| Finance, insurance, and real estate (FIRE) | 8.0* | 10.3* | 11.8* | 12.4 | 12.3 |
| Services | -6.2 | -7.0 | -13.9 | 0.1 | 9.1 |
| Federal, civilian government | -6.8* | -4.4 | 0.7 | -2.7 | -4.9 |
| Federal, military government | 0.0 | 1.0 | 0.8 | 0.2 | -2.9 |
| State and local government | 1.7 | 1.3 | 6.1 | 4.9 | 2.8 |

* Asterisk indicates statistically significant from zero, a=.10.

**Table 4. Regression analysis of employment growth rate differences.**

| | ß | t-value |
|---|---|---|
| Intercept | -59.98 | -0.178 |
| **PURP** | -104.04* | -2.559 |
| **STOR** | 0.02 | 1.016 |
| **START** | 10.92 | 1.487 |
| **CITY100** | -1.20* | -1.998 |
| **LPTPP** | 2.29* | 3.035 |
| **WATAREA** | -0.81 | -0.250 |
| **MAHAL** | 3.65 | 0.409 |
| | | |
| N | 48 | |
| $R^2$ | .24 | |
| Mean difference | 25.8 | |

* indicates statistically significant from zero at a=.10 level.

**Figure 1. Large Dam Completion by Year, 1830-1994**

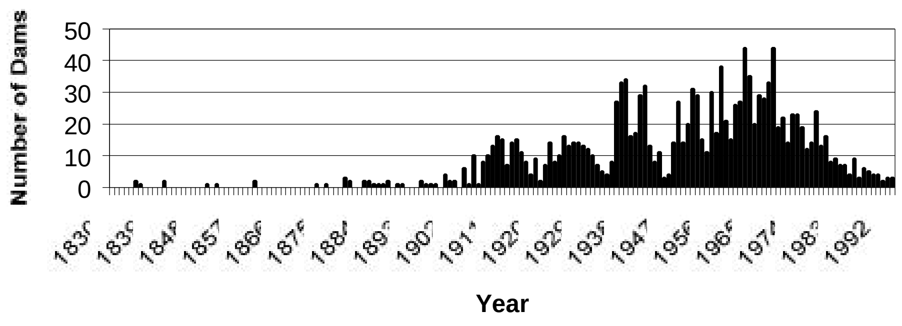
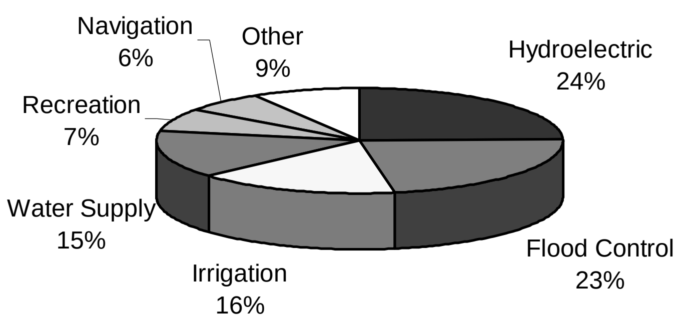



**Figure 2. Large Dams by Primary Purpose**



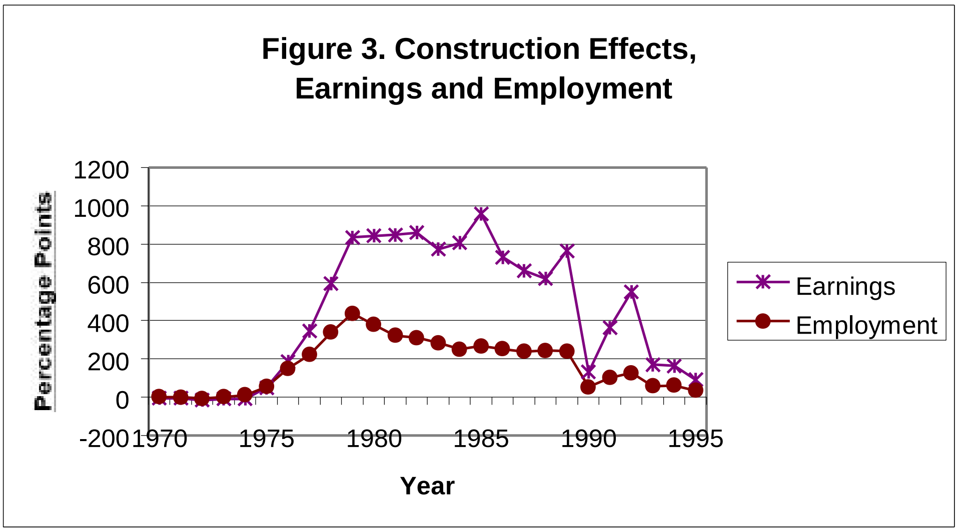


Figure 3. Construction Effects,
Earnings and Employment
1200
1000
800
600
400
200
0
-200
1970
1975
1980
1985
1990
1995
Percentage Points
Year
Earnings
Employment

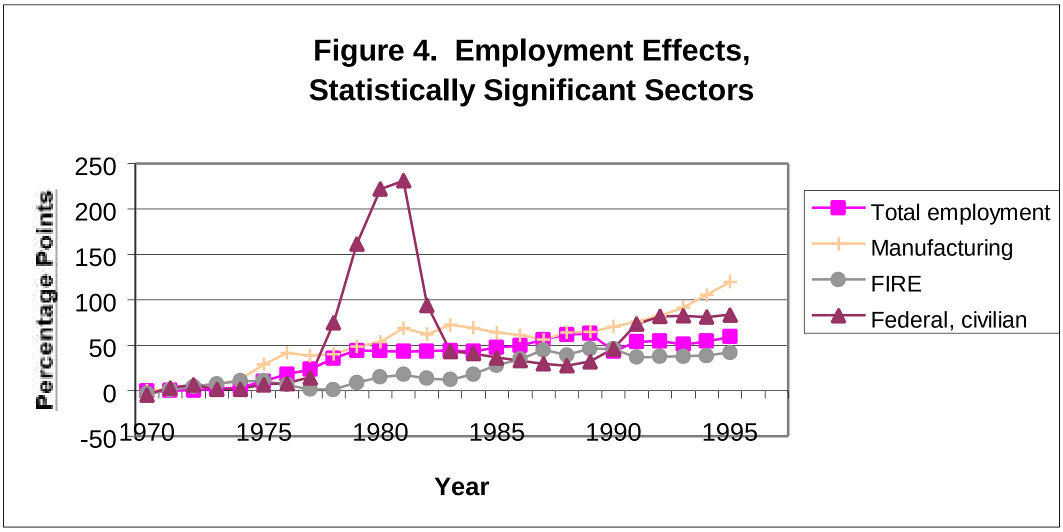


Figure 4. Employment Effects,
Statistically Significant Sectors
250
200
150
100
50
0
-50
1970
1975
1980
1985
1990
1995
Percentage Points
Year
Total employment
Manufacturing
FIRE
Federal, civilian

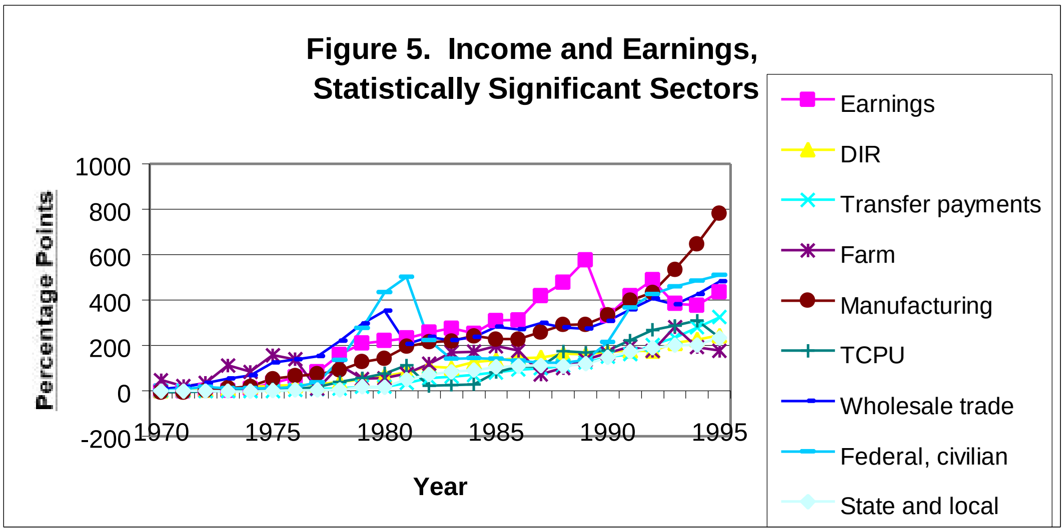


Figure 5. Income and Earnings,
Statistically Significant Sectors
Percentage Points
1000
800
600
400
200
0
-200
1970
1975
1980
1985
1990
1995
Year
Earnings
DIR
Transfer payments
Farm
Manufacturing
TCPU
Wholesale trade
Federal, civilian
State and local