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Why do large public works projects that demonstrate a poor benefit-cost relationship from a national point of view continue to receive strong support from local politicians and interest groups? The Garrison Diversion Project in North Dakota, the Warrior-Tombigbee Navigation Project in Tennessee and Alabama, the Animas-LaPlata and the Narrows Projects proposed for Colorado, are all water projects that, under broadly accepted standards for benefit-cost analysis, exhibit a negative present value of net benefits, a benefit/cost ratio of less than 1.0. Yet each continues to be declared critical or of great importance to the state or region by governors, Congress, and private interest groups. Clearly, if such projects were eliminated, the Gross National Product (GNP) would be larger and, in theory, all states could be made better off.

Several hypotheses have been postulated to explain why these projects retain such local popularity, but there have been few empirical studies of this phenomenon. In this article, the *ex post* benefits and costs of a major water project, the Colorado–Big Thompson Project (C-BT), are analyzed from national and project region viewpoints. The methodological issues involved in measuring benefits and costs from these viewpoints are first reviewed. The empirical analysis then demonstrates the vast differences in perception of projects from the national and regional viewpoints and illustrates the distortions that enter the data typically presented to the public concerning project benefits and costs.

METHODOLOGICAL ISSUES IN CARRYING OUT EX-POST BENEFIT-COST ANALYSIS

Two major issues dominate the design of either *ex-ante* or *ex-post* benefit-cost analyses: the specification of the area over which benefits and costs are to be counted and the monetary unit of account in which benefits and costs are calculated. The specification of the area is often

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referred to as determining the "accounting stance" to be taken in counting benefits and costs.[1] In an ideal sense, the accounting stance would be global; benefits and costs resulting from a project would be counted wherever they might appear in the world. The accounting stance most often taken is national; only the benefits and costs accruing to the nation where the project is located are counted. Ignoring impacts on other nations has proved to be shortsighted and can result in later, costly attempts to ameliorate the international impacts. A prime example is the Welton-Mohawk Irrigation Project in Arizona which substantially increased the salinity of the Colorado River at a point just before it flows into Mexico. The resulting damages to Mexican agriculture were not counted in the benefit-cost analysis of the project and the political repercussions were so strong that Presidents Nixon and Echevarria met to negotiate a solution, one that turned out to be extremely costly and inefficient.[2] In an age of technologies sufficiently powerful to pollute air and water on a global scale, this global-national distinction is increasingly important.

Within a nation, different governmental units and interest groups will have their own accounting stances. A regional group of states[3] is likely to evaluate proposed projects or policies in terms of benefits and costs accruing to that group of states. A state government is likely to behave similarly, as are sub-state regions and special districts. While it would be desirable to have each of these units magnanimously consider all the consequences of its actions, one cannot fault the narrower accounting stance chosen by sub-national units since that choice is largely motivated by national laws and regulations that affect the geographical incidence of benefits and costs.

The geographical incidence of project benefits and costs within a country is determined by at least four categories of factors: (1) location of the project; (2) physical inputs and outputs of the project; (3) adjustments of market prices, incomes, and employment resulting from the project; and (4) rules, usually at the national level, governing the sharing of project costs. It is likely that most project benefits will accrue to the project region, but this can be affected by the nature of project inputs and outputs. Major inputs may have to be acquired from other regions, thereby benefitting those regions, while market responses to project outputs may change prices of those outputs enough to affect the distribution of benefits between producers and consumers of these outputs.

Some project impacts that flow across political boundaries may have no prices or penalties attached to them[4] and are thus likely to be omitted

1. C. Howe, Benefit-Cost Analysis for Water System Planning, ch. 2 (1971).

2. Oyarzabal-Tamargo & Young, *International External Diseconomies: The Colorado River Salinity Problem in Mexico*, 18 Nat. Res. J. 77-89 (1978).

3. For example, the states represented in the Western Governor's Association.

4. *E.g.*, water, air, and noise pollution.

from the project region's counting of costs. Rules regarding reimbursement of costs to the national government are important determinants of the incidence of costs. For example, the costs of flood control storage in U.S. Bureau of Reclamation projects are classified as "non-reimburseable" and do not have to be repaid either by project beneficiaries or by the special district contracting with the Bureau for purchase of project outputs. These national costs are paid by tax-payers at large.

Direct and Secondary Benefits and Costs: Relationship to the Accounting Stance

Direct benefits and costs are those tied to the project itself, benefits in the form of project outputs and costs in the form of project construction or operating inputs. Secondary benefits and costs are those that arise in economic activities that process project output or produce inputs for the project's construction and operation. Secondary benefits take the form of new productive factor incomes, including profit, in these linked activities. Secondary costs take the form of lost productive factor incomes in those activities from which the factors were attracted, including the possibility that they were formerly under or unemployed. Secondary benefits and costs are difficult to measure and are often omitted from benefit-cost analyses at the national level.

Secondary benefits and costs are likely to be important for state or sub-state accounting stances since the secondary benefits are likely to accrue to the project region while secondary costs are more likely to be shared with other regions. For example, the added incomes from the processing of project agricultural outputs and the provision of inputs such as fertilizer and machinery are likely to accrue largely to the project region. The inputs needed to expand those linked activities had to come from other activities which were thereby forced to curtail their outputs. These reductions constitute the secondary costs and can occur both within and outside the project region. Insofar as these productive factors, including capital, are attracted from outside the project region, the loss of their outputs elsewhere will not be counted as costs in the project region's assessment of the project.

Pure transfers of activity to the project region may also occur as a result of the project and be counted as benefits by the project region even though they do not represent any increase in overall economic activity. An example might be a food processing plant located in Kansas that decides to relocate in Colorado, partly to be able to process the output of a new Colorado irrigation project. The plant continues to process agricultural outputs from Kansas as well. This part of its activity would be a pure transfer and would cancel out from a national accounting stance, while Colorado would count all of the plant's value-added as a state benefit.

The Monetary Unit of Account

Benefit-cost analysis reduces the positive and negative impacts of a project to a single monetary value: the present value of net benefits (PVNB).[5] If a project has an expected lifetime of T years, this PVNB can be expressed as:

$$PVNB = \frac{B_1 - C_1}{(1 + r)} + \frac{B_2 - C_2}{(1 + r)^2} + \ldots + \frac{B_T - C_T}{(1 + r)^T}$$

where the B_T and C_T terms represent the annual benefits and costs in monetary terms. For PVNB to be a meaningful measure, the benefits and costs of the various years must be expressed in monetary units, such as dollars, of equal purchasing power. For example, suppose a project had identical physical outputs and inputs in each year of its life, while the national economy was experiencing uniform, rapid inflation of 20 percent per year. If the physical inputs and outputs were evaluated in terms of this increasing price level, the second year's net benefits, B_2-C_2, would appear to be 20 percent greater than those of year one; the third year's nominal net benefits would appear to be 44 percent higher, and so forth. To avoid this kind of distortion, it is necessary to apply the price level of a base year to the valuation of project inputs and outputs throughout the project's lifetime.[6]

This poses no problem for *ex-ante* cost analyses, for the analyst simply uses the prices that exist at the time of the analysis. For *ex-post* analyses, however, changing price levels pose a major problem. In the Colorado–Big Thompson case, construction started in 1938, with operations continuing through 1980. During this time, the general price level increased about 300 percent while water project construction costs increased even more. The problem requires the choice of one or more appropriate price indices that can be used to deflate or inflate prices of later years to the level that existed in the chosen base year.

The other key parameter in that equation is the discount rate, r. Since the various benefits and costs occur at different points in time, adjustments for timing must be made to reflect the fact that a dollar received or spent today is not the same as a dollar received or spent in earlier or later times, if only because of the interest income or expense that could be earned or delayed.[7]

5. HOWE, *supra* note 1, ch. 5. Multiple objective planning is an attempt to extend benefit-cost analysis to several non-monitized dimensions such as environmental and social impacts. *See* D. MAJOR & R. LENTON, APPLIED WATER RESOURCE SYSTEMS PLANNING (1979).

6. Changes in relative prices over the project's lifetime must be incorporated in the analysis, i.e., even with a stable general price level, some prices would change as a result of changed scarcity conditions. Such changes must be reflected in the analysis.

7. The most thorough and up-to-date summary and analysis of the discount rate controversy is R. LIND, DISCOUNTING FOR TIME AND RISK IN ENERGY POLICY (1982).

Thus, when carrying out an *ex-post* benefit-cost analysis from any accounting stance, it is necessary to adjust all benefit and cost figures to prices of some base year. It also is necessary to discount all such adjusted benefits and costs to some base year, usually the same year as that chosen for the price level adjustments.[8] With these factors in mind, a description and *ex-post* benefit-cost analysis of the Colorado–Big Thompson (C-BT) Project from both national and project region accounting stances is presented.

THE COLORADO-BIG THOMPSON PROJECT AND THE NORTHERN COLORADO WATER CONSERVANCY DISTRICT

If one were to start at Boulder, Colorado and draw one line straight north to the Wyoming border and another straight east to the Nebraska state line, the resulting rectangle within Colorado would include all of the lands directly served by C-BT.[9] On the western side of the Rockies, a series of reservoirs captures part of the flow of the Colorado River and its tributaries. This water is pumped to an elevation which allows it to flow through a tunnel to the eastern side of the mountains. On that side, electric power is produced at several points. At lower elevations, the water is channeled into natural streams and feeder canals for distribution. A large reservoir on the western side of the mountains is not part of the system in a physical sense but was constructed to provide replacement water for that diverted from the Colorado River for C-BT. The federal government retains and operates all the collection works and electric power features while the Northern Colorado Water Conservancy District (NCWCD), which was established in 1937 to contract for and distribute the water; must provide for the "perpetual care, operation, and maintenance" of all the water distribution works.

The NCWCD region is semiarid with average annual precipitation of 13.7 inches. The long-term average annual runoff is 1.1 million acre-feet. The C-BT project has provided an historical average of 230,000 acre-feet or about 17 percent of the total water supply of the region. This supply is used primarily for supplemental irrigation, but towns and a growing number of non-agricultural industries are increasingly using C-BT for raw water supply.

The NCWCD entered into a contract with the United States in 1938, specifying the obligation of both parties for the C-BT project. The repayment contract of 1938 contained some features that would greatly

8. For a thorough treatment of these issues and others involved in ex-post analysis, *see* R. HAVEMAN, THE ECONOMIC PERFORMANCE OF PUBLIC INVESTMENTS: AN EX-POST EVALUATION OF WATER RESOURCES INVESTMENTS (1972).

9. U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION, THE STORY OF THE COLORADO–BIG THOMPSON PROJECT (1968, revised).

influence the incidence of project costs. These features included: (1) the allocation of costs between power and water supply; (2) the rules for repayment by NCWCD of costs allocated to water supply; and (3) an upper limit of $25 million on the District's total repayment obligation. At the time, the estimated construction cost was $44 million, but it later escalated to $164 million. In keeping with reclamation law, repayment was to be over a forty year period according to an increasing schedule, *without interest.*[10] The value of these provisions to the District was almost surely not appreciated at the time.

Regional and National Conflicts Over C-BT

Sharp conflicts arose over C-BT, with northeastern Colorado interests pitted against Western Slope interests on one hand and against the U.S. Park Service and allied environmental groups on the other. Resolution of conflicts with Western Slope interests was accomplished prior to June 1937, but controversy with the Park Service and environmental groups continued through the authorization hearings[11] and into November 1937. The resolution of these conflicts helped to determine the costs of the overall project and the responsibility for these costs.

In 1933 a regular series of meetings between northeastern Colorado and Western Slope interests had been undertaken in an attempt to avoid misunderstanding and confrontation. The key Western Slope parties were Congressman Edward T. Taylor of Glenwood Springs, then Chairman of the House Appropriations Committee, and Walter Walker, publisher of the *Grand Junction Sentinel.* Under their guidance, the Colorado River Protective Association was organized to defend against any incursions into Colorado River water supplies. In April 1934 a Northern Colorado Water Users Association delegation traveled to Grand Junction to open negotiations on a plan that it was hoped would benefit both East and West Slopes, at federal expense. The Western Slope position was a "foot-for-foot" compensatory scheme in which C-BT would be required to construct an acre-foot of new Western Slope storage for every acre-foot of average annual diversion to the Eastern Slope. An agreement to build Green Mountain Reservoir was hammered out by representatives of the two associations and the Colorado congressional delegation in June of 1937.

Other fights were still being waged. In 1934, the Bureau of Reclamation wanted to undertake a full survey of C-BT but the Park Service informed the Bureau that no surveys would be allowed in Rocky Mountain National Park. This position was strongly supported by the National Parks Asso-

10. U.S. Department of the Interior, Bureau of Reclamation, Colorado–Big Thompson Project, Synopsis of Report on C-BT, Plan of Development and Cost Estimate 24, S. Doc. No. 80, 75th Cong., 1st Sess. (1937).
11. June 30 and July 2, 1937.

ciation and Secretary of the Interior Ickes. In January 1937 a bill to authorize C-BT was introduced in the Senate. During hearings by the House Irrigation and Reclamation Committee, the opposition came out in full force, based on a desire to protect the National Park lands and to avoid setting precedents of water project incursions into the National Parks. After Congress finally authorized the project and the first appropriation for construction was made in July, 1937, the National Parks Association and others made another attempt to stop the project. But in January 1938 Secretary Ickes announced that President Roosevelt had formally approved the project.

It is interesting to note that no benefit-cost analysis for C-BT was conducted. The Reclamation Bureau's survey report concluded that a construction cost of $44 million for the project, the sale of power, and the sale of water at $2 per acre-foot was financially feasible.[12] Estimates were presented of the water "shortage" in the intended project area—575,000 acre-feet which would largely be covered by C-BT deliveries of 310,000 acre-feet plus associated multiple return flows.[13] Average annual losses in gross crop value due to water shortage were estimated to be $4.7 million, and it was observed by the Bureau that water rental prices in the area averaged about $4.50 per acre-foot.[14] No attempt was made to draw any formal conclusions from this. Secretary Ickes voiced doubt about the "feasibility" of the project, but he seemed to be referring to repayment, rather than to economic, feasibility.[15]

Construction of the C-BT began in 1938, but was interrupted in 1942 by World War II priorities. The first deliveries of water into natural streams on the Eastern Slope were made in 1947, and full water deliveries commenced in 1957.

PROJECTED AND ACTUAL COSTS OF C-BT

In this section, the costs of the C-BT project as forecasted at various points during project planning and construction and the actual costs are exhibited. The issues raised earlier regarding accounting stance and comparable dollars will be explicated in terms of the C-BT experience. This will provide us with the cost side of a complete *expost* benefit-cost analysis.[16]

12. U.S. DEPARTMENT OF THE INTERIOR, *supra* note 10, at 33.

13. *Id.* at 7-8.

14. *Id.* at 8.

15. J. DILLE, A BRIEF HISTORY OF THE NORTHERN COLORADO WATER CONSERVANCY DISTRICT AND THE COLORADO-BIG THOMPSON PROJECT 38 ff (1958).

16. *Ex-post* benefit-cost analyses examine the actual performance of projects at some point during the operating life of the project. Their main value lies in what is learned about shortcomings in the pre-project planning process and about project operations. This feedback is essential to the improvement of project planning and management but is seldom carried out because sponsoring agencies

Table 1 exhibits various cost statistics for C-BT.

Table 1. Summary Cost Data for C-BT and NCWCD
(millions of dollars)

Original construction cost estimate, 1937[a]	$ 44.0
Revised United States Bureau of Reclamation estimate, 1946	128.1
Revised United States Bureau of Reclamation estimate, 1952[b]	162.6
Reported final project cost	163.0
Total C-BT project costs from 1937 through 1953 (project completion) in 1960 dollars[c]	443.3
Total national C-BT and NCWCD construction and operation costs through 1980, in 1960 dollars[c]	550.7
Project region total C-BT and NCWCD costs through 1980, in 1960 dollars[d]	107.9

a. U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION, COLORADO–BIG THOMPSON PROJECT, SYNOPSIS OF REPORT ON C-BT, PLAN OF DEVELOPMENT AND COST ESTIMATE, S. DOC. NO. 80, 75th Cong., 1st Sess. (1937).
b. UNITED STATES BUREAU OF RECLAMATION, COLORADO–BIG THOMPSON PROJECT, ADDENDUM TO DEFINITE PLAN REPORT, 1952.
c. Costs indexed to 1960 and discounted or computed to 1960.
d. Includes actual payments made by parties in project region, including payment for electric power.

The cost data reflected in Table 1 indicate that actual costs deviated from early projections. It also illustrates the importance of clarifying the basis used for cost comparisons. The main conceptual issues are whether the values are measured in dollars of comparable purchasing power, whether they are appropriately discounted to allow for differences in timing, and whether the accounting stance being assumed is made clear. The original construction cost estimate of $44 million was a projection of anticipated costs in terms of prices prevailing in 1937. This is standard procedure in planning and benefit-cost studies. Certainly, after several years of falling prices during the depression, there was no reason to anticipate future price increases. The 1946 re-estimate of $128.1 million is conceptually confusing, because it contains both costs actually incurred up to that date and costs still to be incurred up to project completion. Prices generally began rising in 1939 and continued to rise slowly during World War II when most prices were controlled. The *Engineering News Record* (ENR) building cost index (1960 = 1.00) increased from 0.35

stand to be embarrassed by the comparison of actual with projected performance. For examples of *ex-post* analysis, *see* HAVEMAN, *supra* note 8; Freeman, *Six Federal Reclamation Projects and the Distribution of Income*, 3 WATER RESOURCES RESEARCH no. 2, at 319-32 (1967); and Fox & Herfindahl, *Economic Efficiency in Project Evaluation: A Study of U.S. Army Corps of Engineers Projects*, 50 AM. ECON. REV. PAPERS AND PROC. no. 2, at 205-17 (1964).

in 1938 to 0.47 in 1946, later to rise to 1.52 in 1970 and 3.57 in 1980. Thus the 1946 cumulative costs consisted of dollars of differing purchasing power representing different amounts of real inputs per dollar, while the future costs were projected in 1946 prices. The same can be said of the re-estimate of 1952 and the reported final project cost.

To make the cost figures comparable, it is desirable to convert each year's dollar cost into dollars of a constant purchasing power before summing them. The ENR building cost index was chosen to adjust all dollar costs to the input purchasing power of a dollar in 1960. The choice of 1960 as a base year was made to avoid indexing the large construction expenditures over too long a period. Costs will thus be expressed in dollars of 1960 input purchasing power, and all costs will be discounted or compounded to 1960.

Discounting to allow for differences in timing of costs is the second conceptual issue in Table 1. While arguments over the appropriate discount rate continue,[17] the essential point is that costs incurred today are not equivalent to costs incurred earlier or later. Further, once all the cost figures have been reduced to dollars of constant purchasing power, an inflation-free discount rate is required.[18] For this study, a discount rate of 5 percent has been used. Thus, the 1960 present value of a cost C_t incurred in year t is calculated as follows:

$$PVC_{1960} = C_t(1.05)^{1960-t}$$

The final conceptual issue of Table 1 is that of the accounting stance: national or project region. In the project region stance, the financial repayment arrangements with the federal government are crucial, as are issues of liability for adverse downstream effects. Regarding the former, NCWCD contracted to pay 50 percent of all project costs, subject to an upper limit of $25 million—perhaps a reasonable limit given the initial cost estimate of $44 million. However, while costs escalated rapidly, the limit on repayment was maintained. Given the forty year interest-free repayment period that began in 1962 and the continuing reduction in the value of the dollar due to inflation, the real repayment obligation has become quite small in real purchasing power terms.

C-BT also uses water that formerly was being used in the lower Colorado River Basin, and the project also increases the salinity concentration in the lower basin by removing high quality water from the headwaters area. These are real economic costs, even though NCWCD has never been held liable for them. The components of cost to be counted under national accounting stances are: 1. Construction costs, including land

17. *See* LIND, *supra* note 7, and Hanke & Bradford, *On the Discount Rate Controversy*, 28 PUB. POL'Y. no. 2 at 77-83 (1980).

18. *See* HOWE, *supra* note 1, ch. 5.

costs; 2. United States Bureau of Reclamation operating and maintenance costs; 3. NCWCD construction, operation and maintenance, and administrative costs; 4. Construction and operating costs by various entities for recreation; 5. Opportunity costs of water diverted; and 6. Salinity costs imposed on the Lower Colorado Basin. Project region accounting stances would include: 1. Repayment of construction costs to the federal government; 2. NCWCD share of United States Bureau of Reclamation operating and maintenance costs; 3. NCWCD construction, operation and maintenance, and administrative costs; 4. Payments to United States Bureau of Reclamation for wholesale hydro-electric power received; 5. Construction and operation costs for recreation.

Table 2 presents the national cost components, all indexed to 1960 dollars according to the ENR Building Cost Index and discounted or compounded to 1960, while Table 3 presents the regional cost components.

Table 2. 1960 Present Value of National C-BT/NCWCD Costs Through 1980
(millions of 1960 dollars)

United States Bureau of Reclamation construction and operation costs 1937–53	$443.3
United States Bureau of Reclamation/NCWCD construction costs, 1954–80	25.7
United States Bureau of Reclamation and NCWCD operation, administration and maintenance costs	24.2
Recreation construction and operation costs	1.5
Opportunity cost of water diverted since 1957	30.8
Salinity costs to Lower Colorado Basin	25.2
Total	$550.7

Table 3. 1960 Present Value of NCWCD Regional Costs Through 1980
(millions of 1960 dollars)

Repayment of construction costs to federal government through 1980	$ 3.7
NCWCD share of United States Bureau of Reclamation operating and maintenance costs	11.4
NCWCD operations and maintenance, and administrative costs	5.6
Payments to United States Bureau of Reclamation for wholesale electric power	85.7
Construction and operation costs for recreation	1.5
Total	$107.9

The main conclusions that emerge are that the nominal cost figures usually quoted for this project have little relation to the real costs of the project and that there are very large differences between the real cost imposed on the nation and those imposed on the project region. Both points are of key importance to *ex-post* project evaluation and to understanding regional motivation for promoting federally financed water projects.

EX-POST ANALYSIS OF NATIONAL AND PROJECT REGION BENEFITS OF THE C-BT/NCWCD SYSTEM

The preceding section presented the *ex-post* analysis of C-BT/NCWCD costs in terms of present values of dollars of a common purchasing power. The remaining half of a complete *ex-post* analysis is to estimate the benefits of the project in similar terms. The realized net benefits of C-BT/NCWCD are conceptualized as the difference between the actual state of the national or regional economy as it grew with C-BT/NCWCD in place and as it might have been had the project not been built. The with-without comparison is simple in principle but difficult to carry out. Because of the pervasiveness of the effects of the project throughout the project region, estimating the development of the region without the project requires a regional modeling approach and a number of strong assumptions that will be controversial. The "project region" first needs to be clearly defined. It could be confined to the boundaries of NCWCD itself, but the District is part of a larger, highly-integrated multi-county region of northeastern Colorado. Data availability is also on a county basis, so the project region shall be defined as a six county region.[19] This region includes all of the South Platte River downstream from the core of the District where nearly all of the C-BT water is initially applied and thus encompasses the areas in Colorado that benefit from Project return flows.

Further analysis is facilitated by breaking down the regional economy into the following sets of economic sectors: (1) irrigated agriculture; (2) dryland agriculture; (3) major agriculturally-linked sectors, livestock and food processing; (4) export-oriented sectors; and (5) general support sectors. The existence of C-BT/NCWCD most directly affects irrigated agriculture but as irrigated acreages change, dryland acreage will also change. Those sectors that provide inputs to agriculture, known as backward linkages, and that process agricultural output, known as forward linkages, are indirectly affected and have their own patterns of water use.

The export oriented sectors are those producing for a national market or, in other words, products for which demand can be taken as exogenous

19. Larimer, Boulder, Weld, Morgan, Logan, and Sedgwick Counties.

to the region. The growth of these sectors is assumed to be the same *with* and *without* the project because of the exogenous nature of the demand for their output, because they are not heavy users of water, and because they have little linkage to agriculture. The export-oriented sectors are mining and extraction, metals and electronics components, printing and publishing, and miscellaneous manufacturing. The "agriculturally linked" sectors, not discussed above, including households, are the general support sectors that indirectly provide inputs to the agricultural, agriculturally linked, and export-oriented sectors and their associated populations.[20]

The approach to estimating the state of the regional economy as it might have grown without C-BT/NCWCD is clearly the most speculative part of this study. Yet it cannot be omitted, for any assertions that C-BT/NCWCD has been highly productive, important to regional growth, and a good investment, must be based on some understanding of what things would be like today if C-BT/NCWCD had never existed. The keys to the analysis are the estimation of national and regional project benefits as different percentages of the project's regional value added and the assumption that irrigated agriculture and the agriculturally linked sectors would have to absorb the reduction in water availability that would have been caused by the absence of C-BT/NCWCD. The without-project estimated average annual decrease in the value of irrigated outputs was projected to be $52 million and the average annual increase in value of dryland crops was $6.6 million.[21]

There is no question that the availability of Project agricultural outputs and the related demands for inputs led to the expansion of both forward (output processing) and backward (input supplying) linked activities in the project region. The sectors that are strongly forward linked to agriculture in the region are livestock and food processing. The markets for these final products are found almost completely outside the C-BT project region. It seems reasonable to argue that, had C-BT not existed, the additional supplies of these final products would have been produced elsewhere in the western United States. For this reason forward linkages can be ignored when computing net income changes from the national accounting stance, although not from the project region stance.

The region was continuously growing in economic activity and population during the project lifetime and factors of production were being drawn into the region. The 1957 through 1980 period was also a period

20. The classification of sectors and the input-output model on which subsequent analysis is based are from Gray, McKean & Rohdy, *Estimating Impact of Higher Education from Input-Output Models: A Case Study*, 12 ROCKY MT. SOC. SCI. J. no. 1 at 37-55 (1975).

21. For greater detail, see C. Howe, D. Schurmeier, & W. Shaw, Innovations in Water Management: An Ex-Post Analysis of the Colorado–Big Thompson Project and the Northern-Colorado Water Conservancy District (June 1982), photocopies available from the Department of Economics, University of Colorado, Boulder, CO 80309-0256.

of relatively full employment nationally. Thus the productive factors attracted to the project and project-related activities from outside and within the project region had opportunity costs. To estimate the annual project benefits from a national stance the following assumptions have been made:

(a) Capital newly employed by the project and project-related activities had a rate of return that averaged 25 percent greater than its opportunity cost. For example, capital that had been earning 20 percent per annum would earn 25 percent in the new project-related activities. That would mean that 20 percent of the payment of interest and dividends from project-related activities would represent a net national efficiency gain.

(b) Labor newly employed by the project and project-related activities experienced a productivity increase over former or alternative employments of 20 percent if already resident in the project area or 40 percent if moving into the project area was necessary. The average of these increases is 30 percent, implying that 23 percent of the payment of wages and salaries would represent a national efficiency gain. Applying these percentages to the direct and indirect changes in payments to households and dividends/interest/rent occasioned by the project, the result is:

1960 present value of national economic
efficiency benefits before project costs, 1957–80
(1960 dollars), from agricultural water use. = \$95.6 million

In the case of electric power benefits from C-BT, it appears that there were net losses in the early years of project life, with quite sizable positive net benefits beginning in 1953:

1960 present value of national economic
efficiency benefits from C-BT electric power
generation (1960 dollars)through 1980. = \$22.0 million

The estimation of recreation benefits requires estimates of the rates of recreation participation and unit values per recreation-day of different activities. With assigned values rising from \$1.50 per day in 1964 to \$7.50 per day in 1980 (the latter figure would be approximately \$18.75 per day in 1980 dollars), recreation values are:

1960 present value of recreation benefits through
1980 (1960 dollars). = \$91.7 million

In summary the estimated national economic benefits of C-BT/NCWCD through 1980 appear to be as shown in Table 4.

Estimating the Project Region Benefits Associated with C-BT/NCWCD

The additional agricultural output made possible by C-BT and the reliability of that added output undoubtedly induced the expansion of the

Table 4. Summary of 1960 Present Value of National Economic Efficiency Benefits from C-BT/NCWCD through 1980 (millions of 1960 dollars)

Direct and indirect benefits from agricultural water use		$ 95.6
Electric power benefits		22.0
Recreation benefits		91.7
	Total	$209.3

livestock and food processing sectors in the region, although probably not nationally. A problem in computing regional income gains is that of estimating what part of the observed expansion of the forward-linked livestock and food products sectors can be attributed to the changes in agricultural outputs. Consideration of the proportions of irrigated outputs going to the livestock and food processing sectors permitted us to allocate the changes in irrigated and dryland outputs to the livestock, food processing, and export sectors. Input-output coefficients then permitted estimates of project-induced changes in annual outputs and in direct agricultural exports to be made. These changes were then treated as changes in regional exports attributable to C-BT/NCWCD and analyzed through the input-output effects on all project-linked sectors of the regional economy. The implied changes in payments to households, dividends, rents, and interest incomes are then computed as before.

The question now is, what fractions of the changes in income payments to households, rents, dividends, and interest represent increases in net regional factor incomes, i.e., net of the opportunity cost of the factors to the region? Assume that one-half of the labor employed by project and project-related activities moved into the region from outside, while the other half changed jobs within the region. For the labor moving in from outside, all income would be new to the region, while labor shifting within the region would experience some increase in productivity over their former employment. It has already been assumed that 17 percent of the labor income of already resident workers would represent a new increase in labor income for the region.

Regarding capital, some would be raised in the region, foreclosing other regional investments, while some would be borrowed from outside. Lacking data, one might assume that one-half was raised regionally and one-half from outside. That raised locally was assumed to experience a 25 percent gain over alternative rates of return. All of the return to capital borrowed from outside the region will be sent outside, representing no gain in regional income. All rental income is assumed to be retained within the regin. The result of this procedure is:

1960 present value of regional factor income increases due to C-BT (1960 dollars).	= $761.1 million

The electric power and recreation benefits computed earlier are assumed to accrue fully to the project region. Table 5 presents the total 1960 present value of regional income increases and other regional benefits through 1980.

A FINAL COMPARISON OF BENEFITS AND COSTS FROM NATIONAL AND REGIONAL ACCOUNTING STANCES

One final task remains in preparing a comparison of benefits and costs from national and regional accounting stances. The cost and benefits presented thus far are through the year 1980. Naturally, the C-BT project and NCWCD will continue into the future, given the excellent maintenance and operation of all facilities under the jurisdictions of the U.S. Bureau of Reclamation and the NCWCD. Thus, it might be assumed that the 1980 levels of benefits and costs, from both the national and regional accounting stances will continue from 1981 into the indefinite future ($t = \infty$). While use of an indefinitely long future may sound unrealistic, a dollar of net benefits in the year 2000 adds only three cents to the present value in 1960, discounting at 5 percent and assuming 3 percent inflation. Extending benefits and costs in this way from 1981 on leads to the following additions to benefits and costs, expressed in 1960 present values of 1960 dollars:

added benefits from the national accounting stance	$145.5 million
added costs from the national accounting stance	41.1 million
added benefits from the regional accounting stance	430.5 million
added costs from the regional accounting stance	9.6 million

Table 5. Present Value of Net Regional Income Increases and Other Benefits Due to C-BT/NCWCD through 1980 (millions of 1960 dollars)

Direct and indirect net regional income increases from agricultural water use		$761.1
Electric power benefits		22.0
Recreation benefits		91.7
	Total	$874.8

Table 6. Summary Table: 1960 Present Value of C-BT/NCWCD Benefits and Costs from National and Regional Accounting Stances (millions of 1960 dollars)

	Benefits	Costs	Net Benefits	B/C Ratio
National:				
through 1980	209.3	550.7	−341.4	0.38
T = ∞	354.8	591.8	−237.0	0.60
Regional:				
through 1980	874.8	107.9	766.9	8.11
T = ∞	1305.3	117.5	1187.8	11.11

Sources: Tables 3, 4, 5, 6 and text.

These figures now permit the final presentation of benefit-cost comparisons, from both national and regional accounting stances, both excluding and including post-1980 benefits and costs. The results are presented in Table 6. We can thus conclude that the project has not yet paid for itself in economic terms from a national accounting stance.

From the regional viewpoint, the project has been of enormous benefit from the beginning. Because of the livestock and food processing activities attracted to this region because of the availability of project outputs, regional income benefits have been much higher than national benefits. Regional costs are very low in comparison with national costs. Thus in total, the regional net benefits appear to be many times the net national benefits.[22]

These results then provide an answer to the question which opened the article: large federal water projects that exhibit negative net benefits from a national accounting stance often remain very attractive to the project region because most of the benefits and transfers of project-linked activities accrue to the project region, while significant project costs are imposed as externalities on downstream parties or defrayed by taxpayers at large.

22. There is extensive evidence that this is true of other western irrigation projects. *See* Young, *Economic Analysis and Federal Irrigation Policy: A Reappraisal*, 24 W.J. Agric. Econ. no. 4 at 257-67 (1978), and North & Neely, *A Model for Achieving Consistency for Cost Sharing in Water Resource Programs*, 13 Water Resources Bull. no. 5 at 995-1006 (1977).