THOUGHTS ON ECONOMIC EVALUATION AND THE WESTERN WATER POLICY WARS

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INTRODUCTION

Federal and state policies regarding water have long been a major source of contention in the western United States (U.S.). Irrigation of agricultural crops accounts for 80-90percent of water consumed in the western United States, and much of the discussion has focused on the role of irrigated agriculture in the regional economy and on justification of public investments in agricultural water supply. Economists have had an increasing role in the debate over whether water supply investments mainly for irrigation are in the larger public interest.

Three economic axioms concerning irrigation development are commonly espoused by citizens and their political representatives in the arid western U.S. These propositions are: that introduction of irrigated agriculture assures rural economic development, consisting of: (1) significant additional profits, income, and jobs on farms; and corollaries, (2) a high social rate of return to public capital investment; and (3) large spinoff employment and business activity in nearby communities. These three expected consequences of ample irrigation water supplies–combined with the belief that irrigated agriculture helps create the self-sufficient local communities sought by Jefferson–have served to justify public subsidies to irrigation. Conversely, loss of irrigation water supplies from depletion of nonrenewing ground water stocks or from transferring water from agriculture to growing cities is seen as imposing large costs on region of origin economies. The "iron triangle" of local interest groups (including native American tribes), federal agencies, and congressional representatives transformed these three theses into public appropriations and subsidies for irrigation water projects or for alternative urban water supply sources to protect existing agricultural regions.

Developing, refining, and applying methods for testing the above three propositions have been the focus of most of my career as a water economist. In what follows, I offer a personal viewpoint on these economic issues that relate to federal and state water policies in the west. The first topic is the economic evaluation of irrigation water supply projects and appraisal of the converse issue of projects or policies which would reduce the amount of water used for crop irrigation. Next I discuss the improvement in the technical aspects of measuring direct economic benefits of new supplies, and the counterpart: foregone benefits of water removed. Finally, I take up the potential role of irrigation development as a source of economic growth in arid-region economies.

ECONOMIC APPRAISAL OF WATER SUPPLY PROJECTS AND POLICIES

The Evolution of Benefit-Cost Analysis (BCA) Applied to Water Resources Planning

Systematic comparison of the estimated benefits with the estimated costs of federal water projects has been required for many years, provisions in the Reclamation Act of 1902 being an early example. However, methods of evaluation were crude by present-day standards, often consisting only of comparisons of expected gross revenues received by beneficiaries with expected total project costs. Associated costs to beneficiaries and foregone benefits from what we would now call nonmarketed goods and services got little or no attention. In the early part of the 20th century, economists (initially in England) began to formulate the methods of normative economic analysis that came to be known as welfare economics. The well-known requirement in the Flood Control Act of 1936 that benefits "to whomsoever they may accrue" must exceed the costs established welfare economics as the conceptual basis for feasibility tests on federal water projects and set the stage for later development and refinement of benefit-cost evaluation techniques.

By the late 1940s a few scholars, mainly working in the "land economics" tradition of agricultural economics, had studied issues relating to water allocation, and worked out methods of estimating economic benefits and costs. Several reports on evaluation methodology were issued from within the federal government, most notably the

Green Book (Proposed Practices for Economic Analysis of River Basin Projects, 1950). However, it was not until the late 1950s when some of the growing number of resource economists began to rigorously adapt microeconomic and welfare economics concepts to public investment and allocation issues relating to water. These economists brought several relatively simple concepts – such as opportunity costs, demand as willingness to pay, marginal analysis, nonmarketed costs and benefits, and distinctions between private and social benefits and costs – to the economic evaluation of water allocation issues, but major changes in policy were implied. My own introduction to these ideas was from the writings of Hirshleifer, DeHaven ,and Milliman (1960), who argued in their analysis of water planning issues in California that the least cost approach among available economically feasible alternative water supply sources should be selected. While Hirshleifer, et al., were not the first to do so, they further urged consideration of nonstructural approaches to water supply problems, in particular, reallocation from low-valued to higher-valued uses. Several other works on water economics appearing about that time were extremely influential with younger researchers such as myself. Otto Eckstein's *Water Resources Development* and Roland McKean's *Efficiency in Government Through Systems Analysis* (both appearing in 1958) provided expositions and critiques of the practices then current in federal evaluation procedures. To one raised with the western ethos of "more water is better," but newly imbued with economic concepts, these works were extraordinarily illuminating and exciting.

At the same time, John Krutilla and Eckstein (*Multiple Purpose River Basin Development*, 1958) emphasized the physical interdependence of water projects within a basin framework, and the fact that water development had an opportunity cost value in alternative uses in the typical case of an already developed river basin, costs that should be routinely taken into account in project appraisals. (This last point seems difficult to get across. Even now, the Bureau of Reclamation's recently revised feasibility study of the Animas-La Plata Project in southwest Colorado gave no consideration to foregone hydroelectric power and other instream benefits linked to consumptive losses from the project, although analysis done with my colleagues indicates that the foregone energy benefits from downstream dams such as Glen Canyon and Hoover will easily exceed the direct irrigation benefits gained from the proposed investment.) Other writers urged the importance of being clear as to the "accounting stance" – the point of view from which the economic feasibility analysis is conducted. If federal monies were to finance the project, a national point of view is appropriate for calculating benefits and costs. In this vein, both Eckstein and McKean vigorously challenged the then conventional federal approach to counting regional secondary economic effects (pecuniary externalities) as benefits to the nation, arguing that except in a few special cases, such impacts were offset by foregone secondary costs elsewhere in the economy and thus were appropriately ignored.

Several other major messages emerged from these writings. One premise was that water should be treated as an economic commodity and that suitably adapted exchange institutions warranted consideration as mechanisms for water allocation. An important insight was that underpriced water resources created an artificial demand for water in urban and industrial, as well as agricultural uses, implying that what were widely perceived as important water "needs" were better understood as merely wants for cheap water. Full cost pricing (perhaps implemented with an increasing block rate structure) was proposed as an appropriate solution to many artificially created "water shortage" problems. Water withdrawal has an opportunity cost elsewhere in a river basin, one that is not registered on new projects unless formal policy efforts ensure it. Another important lesson was that economic benefits are not automatic. For irrigation projects, tangible demand or willingness to pay must be present, based on climate, soils, input supplies, and markets for products. Water demand is subject, as are other commodities, to diminishing returns as the sites with the most suitable conditions are exploited.

MEASURING DIRECT AND FOREGONE ECONOMIC BENEFITS OF WATER

Most uses of water supply are nonmarketed, so estimates of economic benefits must be done by synthetic methods rather than observing market prices. The story of the development and improvement in techniques for measuring benefits of nonmarketed natural resource and environmental goods is well known and documented in numerous books and articles. Advances in theory, econometric techniques, and data collection methods have combined to greatly improve the reliability and acceptability of estimates of nonmarket benefits. The majority of that effort has been directed to methods of valuing environmental public goods from the perspective of the consumer and the household, and most of the literature reflects that emphasis.

However, most withdrawal and consumption of water occurs for use by private, profit-making entities – in irrigated agriculture, and to a much lesser extent in industry. Improving methods for evaluating benefits for these "producers' goods" has been one of my primary interests, so I emphasize this aspect.

Measuring Direct Irrigation Benefits

My reintroduction to the subject of valuing irrigation water came as soon as I began work at the University of Arizona since that subject was a primary purpose of the research effort. Eventually this interest led to personal involvement with western water policy conflicts. My colleague Bill Martin and I were asked to serve in a consulting capacity to do a quick economic appraisal of the U.S. Bureau of Reclamation's (USBR) proposed Central Arizona Project for the State of Arizona. The project was designed to transport water from the Colorado River in western Arizona to the Phoenix-Tucson area for the purpose of replacing ground water withdrawals from aquifers, which were being quickly depleted by pumping for crop irrigation; and also to supply expected rapid growth in the urban areas (and not to be disregarded, to put Arizona's Colorado River water rights to beneficial use before California could claim them). The Bureau of Reclamation analysts had found the project to be economically feasible. However, the cycle of congressional politics of the day was not favorable to the project, and chances for federal funding for it appeared to fading. The state government wanted an estimate of the economic returns to the huge investment and of the ability of prospective beneficiaries (primarily agricultural) to repay principle and interest on the investment.

Estimates of the economic benefits of irrigation developments were then, as now, derived mainly by the "residual" approach. Yields and productive input requirements of crop production are forecast for each year of the appropriate planning period and, with assumptions on product and input prices, converted into monetary terms. Economic benefits attributable to water are calculated as the net income remaining after all non water production costs are deducted from estimated revenues. With an analysis based on Bureau of Reclamation estimates of costs, together with data and methods that we had developed over the previous few years, we soon concluded that the net project direct benefits would be far from sufficient for agricultural water users to be able to repay much of the investment costs. Appalled and dumbfounded by our conclusions and perhaps irritated by our flip comment that the state would be economically better off to pay California to take the water, the client rejected our report, presumably to find analysts who better understood the problem of water supply in an arid region. Assuming that someone would be interested in our findings, we published them in a University of Arizona business college periodical, to an enormously greater criticism from the water establishment.

How did Martin's and my procedures differ from those employed by the USBR? From the formula, it is clear that the residual technique requires a number of careful forecasts on the part of the analyst. These include:

- Which crops will be produced?
- What will be their productivity?
- What will be their quality and selling prices?
- What technology of production will be employed?
- What level of inputs, including water, will be used?
- And what will be the prices of inputs?

We disagreed with their methods on both the revenue and cost sides of the equation, concluding their estimates of revenues were too high, and their estimates of costs too low. The residual technique is extremely sensitive to small variations in assumptions about either the nature of the production function or about prices. A small systematic error in either costs or revenues is multiplied in the size of the residual. I have now come to believe that many systematic biases which inflate net benefits are likely to occur in irrigation appraisal whether in the U.S. or elsewhere in the world (Young, 1996). Some typical biases are discussed below using the Central Arizona Project Analysis as the case example. On the cost side, the typical problem is with underestimation or even omission of certain elements of costs. Omission of costs or opportunity costs of any productive input in effect credits the productivity of that input to the value of water. One continuing issue has been an inadequate accounting for the costs of labor. Bureau of Reclamation procedures did not recognize the opportunity cost of family workers, the most important source of labor on the small farms the bureau anticipated would be the major users of project water supplies. Another major cost issue was the accounting for costs of moving water from the main canal to the actual farm sites where it would be used. In this instance such costs would be quite large, and we felt the USBR estimates gave inadequate attention to these necessary expenditures. Often in residual analyses, no charge for the opportunity cost of land is taken, again crediting the productivity of that resource to water. On the revenue side, two major problems are encountered. The most significant is related to the projections of yields, prices, and therefore revenues. USBR used partial equilibrium procedures to forecast generous growth in yields, but neglected to consider the likely adverse aggregate effects on market price of such output increases. The history of agricultural commodity prices has been a decline in real terms as a result of technological advance, so a more realistic approach would account for likely changes in both prices and productivity. Also, to the extent that agricultural commodity prices are subsidized by federal policy, such prices are overstatements of the value to the nation of the commodities, and therefore overestimate from the national point of view the derived value of irrigation water. A final revenue issue is an overemphasis on the potential for specialty vegetable and fruit production, favored by irrigation proponents because such products appear to generate a high return over operating costs and employ large amounts of labor. However, the high gross margins of specialty crops are misleading – representing a return not only to water, but to the high market and production risks and the entrepreneurial skills inherent in specialty crop production. Moreover, specialty crops rarely account for more than a small fraction (less than one-fifth) of irrigated acreage in the west, so from a national perspective there is no reason to assume that federal incentives are needed to protect against shortages of fruits and vegetables.

Adopting the cautious approach to measuring irrigation benefits outlined above yields few cases of positive net economic benefits to irrigation development proposals. Most prospective irrigation projects will be relatively expensive to build and will not have the advantage of the best soils and climate; the most attractive sites have already been developed.

Enough time has elapsed that the alternative analytic approaches have been given the test of experience. The Central Arizona Project was funded and completed. Even though the water charges were highly subsidized, the actual net incomes to many farmers was insufficient to pay the minimal cost-sharing requirements. Even at this writing, much of the water delivery capacity remains unused. The USBR has allocated much of the capacity to Native American tribes (because, cynics would say, federal law does not require tribes to reimburse the government for any capital expenditures). However, the tribes have not received much project water. Similar stories of uneconomical irrigation projects are found in other recently completed projects. The Navajo Irrigation Project ,serving a portion of the Navajo Reservation in northwestern New Mexico, and the Dolores project in southwestern Colorado, are examples.

Deriving Water Benefits From Regional Economic Models

The "value-added" method to estimating economic benefits of producers' goods is another measurement issue which occupied my attention. The method is based on regional inter-industry (also called Leontief input-output) analysis. This was quite popular as a method several decades ago, particularly by regional economists. What is termed the value added (or Gross Regional Income) in an inter-industry model comprises payments to factor owners in the region. Specifically, it includes payments to: wages and salaries for the work force, rents paid to land and other natural resources, interest and depreciation on capital, to profits, and any imported from outside the region. The method yielded very large estimates of the economic value of water, particularly in industrial uses. Although the value-added approach appears, at first glance, to be similar to the residual method described earlier, it differs in certain key respects. It is now recognized that unless extra care is taken, the method overstates the correct economic value of water as an intermediate good (Young, 1996). From the residual formula described in the preceding section it can be seen that the concept represents the payments to a larger set of inputs than just to water. The returns to water are but a part of value added. Employing the value-added measure generates very large estimates of benefits by erroneously attributing the payments to all inputs as the value of water.

PUBLIC IRRIGATION WATER INVESTMENTS AND REGIONAL ECONOMIC GROWTH

The third thesis mentioned at the outset was that public water projects – particularly those developing new irrigated lands in arid and semiarid areas – create regional economic growth. The federal reclamation program beginning early in the twentieth century was premised on this idea and Franklin Roosevelt's program for moving the economy out of the great depression contained a significant role for water resources development. This final section briefly presents evidence and arguments which support an alternative policy conclusion: that irrigation development may be a less than ideal place to invest scarce public capital, and that such investments would best be assessed with the public taxpayer–who will finance the expenditure– in mind, and not uncritically assuming these investments automatically to be in the public interest.

On the General Role of Natural Resources Development as a Source of Wealth

Because irrigation development is a special case of the general problem of natural resource development, it will be useful to take a quick look at the general economic literature on regional economic growth.

The simplest and most frequently advanced lay persons' explanation for differences in regional economic income, employment, and wealth focuses on disparities in natural resource endowments, including soils, climate, water supply, minerals, fisheries, and forest resources. Rich resource endowments are seen by most nonspecialists as the primary sources of wealth; the policy implication being that public and private investments to exploit these resources are attractive avenues to economic development.

However, for present-day regional or national economies, there is little evidence to support the proposition that natural resource development is a strong engine for regional economic growth. It was true, indeed, at early stages of economic development, the wealthiest and fastest growing economies were those based on temperate climates and abundant resource endowments. However, the supporting data for the hypothesis of natural resource development as an engine of regional economic growth is so limited that analysts such as Higgins and Savoie (1995) devote only a few pages of their definitive volume on regional economic development policy to dismissing natural resource development as a productive avenue for encouraging regional advancement.

This conclusion is justified as follows. The economic wealth of nations is best enhanced when both public and private institutions are designed to channel resources into the areas of the highest return to capital and other resources (net of direct and external costs). Natural resources–along with labor and capital–were the initial factors of production identified by the classical economists. In the early stages of development the supply of the "produced" factor (capital) was limited and technology was primitive. Under such conditions, natural resources did account for a significant part of national output. Nevertheless, in present-day economies, several considerations have shifted the most attractive opportunities from the natural resources arena to other types of public and private investments. In most countries, investments in natural resource development have been pursued for many years, and diminishing returns have long since set in; so few opportunities typically remain for further high return investments. Even when developments yielding high returns to the investing entity are identified, the extractive industries frequently bring with them substantial external (uncompensated third party) costs. Such costs take the form of degraded water or air quality or adverse effects on nonmarketed environmental goods and services. When, subsequently, capital has accumulated, the labor force's skills have improved, technology has advanced, and international and interregional trade in both financial capital and products permit consumption to rise without local self-sufficiency in all consumption goods; natural resource investments are less profitable from society's perspective. An increasingly recognized view, taken to its logical limit by writers such as Simon (1996), is that physical, and particularly human, capital can readily be substituted for natural resources. Natural resource constraints do not seriously limit economic output.

(Interestingly, the views of present-day non-economists on the role of natural resources development as a primary engine of wealth exhibit considerable similarity to ideas espoused by an early school of economists, the "Physiocrats" in 18th Century France. The Physiocrats believed that natural resources, particularly agricultural resources, were the primary basis for wealth. Therefore, economic policy should focus on improving the status of natural resource-based economic activities, which because of what are now called forward and backward linked effects, would directly translate to enhanced regional and national economies. The Physiocrats' views were soon challenged by mainstream economists – Adam Smith, among others – due to the failure to account for the roles of capital, labor, and technologic advance. However, similar ideas about the role of agriculture in an economy continue to be voiced in policy discussions by nonspecialists, particularly those from rural areas.)

<u>Irrigation Development and Regional Economic Growth</u>

This general thesis of the limited potential role of natural resources in regional economic growth can also be applied to the special case of potential irrigation water resources investments. A number of studies of the role of water investments in regional economic growth were unable to find statistically significant effects. These findings can be explained as follows. Food prices were relatively low for most of the twentieth century. Overcapacity due to capital investment and technological advance overcame, for most of the world, the problems of food shortages, so food and fiber prices in real terms have continued to fall. The best sites (those with least cost of development and highest potential productivity) have been long since exploited. Potential water development sites which remain are typically less productive and more costly to complete than those projects already in operation. They may also yield high external costs to third parties and other projects. (For example, new water storage may reduce the amount available to existing downstream reservoirs, a situation reached some time ago in most river basins in the west). Labor-saving technological advances in agricultural production and processing have led to a situation in which investment in food-producing capacity adds minimally to farm and regional employment. Only water resource developments whose benefits are highly valued (such as municipal and industrial water supplies in rapidly growing regions) are likely to yield a competitive rate of return while still being able pay to mitigate environmental damages.

A concluding note: probably the major shift in the western water policy arena over the years of my involvement is the shift away from complete dominance of the withdrawal uses of water in policy decisions, towards an increasingly important role for instream environmental and recreational values. The progress in economic analysis has contributed to this shift in two ways. First, the introduction of more realism and rigor into the evaluation of water use in private producers' goods has changed the perception of the role of water in regional economies to a more realistic one. Second, the evidence on the public's increased value of environmental resources together with numerous estimates of significant public willingness to pay for environmental preservation have aided in the recognition of those interests in water policy. Although economic efficiency in allocating water among off stream and instream uses and water quality have not yet been fully achieved, we can be encouraged by the degree of progress and prospects for the future.

AUTHOR

Robert A. Young – After completing a degree in applied agricultural sciences in California in 1954, fulfilling a military obligation, and working for a time, I completed a doctorate in Agricultural Economics with a minor in politics and philosophy at Michigan State University in 1963. With roots in the west, it was natural to then go to the University of Arizona primarily as a researcher on an early water economics study. Participation in an interdisciplinary approach to ground water policy modeling at Resources for the Future from 1968-1970 cemented my focus on water economics and policy issues, an emphasis since then continued at Colorado State University.

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