The Secondary Economic Impacts of Irrigation Development in Washington

Jill L. Findeis and Norman K. Whittlesey

Two potential projects in Washington are examined for their secondary impacts on the economy of the state. A major impact of these projects is to increase the energy costs to regional power consumers. After accounting for the negative impacts of rising energy costs, the long run state level residual income increases by $209 million after irrigating an additional 700,000 acres. The distribution of potential benefits is uneven among sectors of the economy and some sectors will possibly experience substantial decreases in returns to stockholder equity as a result of irrigation expansion.

A primary concern of U.S. agriculture today is how to reduce production in order to increase crop prices and farm income. Since production control is also a concern in irrigated areas, it is fair to ask why irrigation development remains so publicly and politically popular. This report assesses one possible answer, that secondary impacts of developing additional irrigated acreage provide the basis for the political popularity of irrigation projects. The analysis pertains to two major development areas in Washington: the first a U.S. Bureau of Reclamation financed irrigation project of about 585,000 acres and the second an area to be privately developed containing an estimated 221,000 acres of irrigable land. This paper projects the impacts that future development of these areas could have on the state's economy, and discerns both the positive and negative impacts of such development.

Benefits and costs of development fall into four categories: (1) direct primary, such as the value of production and costs of construction, (2) indirect primary, such as energy opportunity costs, (3) in-state secondary, such as business growth or decline, and (4) out-of-state secondary. This analysis examines the impacts of in-state indirect primary and secondary activity that might be stimulated by irrigation development, and examines the distributional implications of additional development in Washington State.

In Washington, the water used for irrigation is provided primarily by the Columbia River and its tributaries, which simultaneously supports a vast network of hydroelectric generation facilities. In addition, the Columbia River system provides water for other instream and withdrawal uses: fisheries, recreation, waste disposal, inland navigation, and wildlife enhancement. Until recently, water resources in this system were not considered to be totally employed, and irrigation in the Northwest did not compete significantly with other water uses. The situation has changed, however, and now there is

---

Jill L. Findeis is assistant professor of agricultural economics at Pennsylvania State University. Norman K. Whittlesey is professor of agricultural economics at Washington State University.

The authors wish to acknowledge the very helpful assistance of Professors Walter R. Butcher and Leroy L. Blakeslee during the conduction of this study. Washington Agricultural Research Center Scientific Paper Number 6857.

Western Journal of Agricultural Economics, 9(2): 233–243

strong competition between irrigation and other uses of water, particularly hydroelectricity production.[1]

As additional land is irrigated, more water is diverted from the Columbia River system, affecting both energy supply and energy demand. The water diverted to agriculture reduces the capacity of the hydropower system. Also, electric energy is used in the irrigation process itself to operate the machinery needed to lift and distribute water to irrigated land. Since new, more expensive thermal energy facilities must be constructed if the electricity used and "lost" as a result of additional irrigation is replaced to meet electricity demands, a potential problem is created for the regional economy. It is important to evaluate whether irrigation development be pursued in light of the problems the additional energy requirements create.

Whittlesey *et al.* found that the direct costs of new irrigation development in both study areas including the costs of investment in the delivery system and the opportunity costs of land, water, and energy used, were far greater than the net returns from farming the lands after development. The economic feasibility analyses in that study did not consider the large energy costs imposed on the public by irrigation development. In the U.S. Bureau of Reclamation's East High Project (EHP), the publicly imposed costs of energy will exceed $225 per acre per year, while energy costs will exceed $190 per acre per year in the privately developed Horse Heaven Hills (HHH). These costs will be borne by consumers of electricity in the region through increased utility rates.

Aside from the issue of public energy costs imposed by irrigation growth, the present economic situation is not favorable for further development. Particularly in the EHP, large capital subsidies to developers will be necessary to induce irrigation growth. The USBR estimates that the payment capacity of farms in that area to be about $46 per acre per year, including operation, maintenance, and repair costs, while the capital costs of development will exceed $5,000 per acre. Farmers are expected to repay about $1,500 of the cost over a 50-year period with no interest charges, providing a present value of about $125. The remainder, including all interest charges, will become a subsidy. The economic rationale for developing lands in the HHH is more favorable. However, even there, some capital or interest subsidies will be required to bring about full development. Should some of the direct costs of new irrigation development be subsidized? If so, who should pay these costs?

This study sought to shed additional light on the desirability of irrigation development in Washington by estimating the secondary impacts of this activity on the state's economy. If more agricultural land is irrigated, producers and consumers will be affected by (1) increased agricultural output and the primary and secondary benefits and costs associated with expansion in the agricultural production sectors, and (2) higher electricity rates resulting from a greater reliance on nuclear and coal fuels to provide the region's electricity supply. Input-output (I-O) was used to measure the simultaneous impacts of these effects on the Washington economy. The study was expected to show increases in state-level employment and income attributable to additional agricultural production. These positive effects were measured under two alternative production scenarios.[2] Scenario I represents what might occur immediately following completion of construction, including only backward linkages to the livestock, meat products, dairy products, and canning and

[1] For example, see Wharton; Hastay *et al.*; U.S. Army Corps of Engineers; Wilkins; and Whittlesey *et al.*

[2] The crop mixes used and the primary benefits associated with development in each of the study areas are detailed in Findeis and Whittlesey.

preserving sectors. The crop mixes and yields for Scenario I are based on irrigated crops currently produced in the study areas, with yields projected to 1985. Scenario II is hypothesized to represent what might occur in the long-run as irrigation development stimulates large-scale expansions of the food processing and livestock industries. Scenario II includes a more sustainable crop mix for long-run market compatibility, with more wheat and less forage crop production. A negative price effect was estimated under Scenario II for both fresh and processed vegetables and fruits due to the expected downward pressure on prices by increased production. Increases in transportation services needed to haul the additional fresh and processed output for export were also included. In addition, the magnitude of the negative effects stemming from higher electricity rates, as well as the sectoral distributional impacts of the induced economic changes, were estimated in an I-O framework.

Methodology

The input-output transactions table reflects the structure of an economy, and can be used to assess the interindustry impacts predicted to occur as direct and indirect results of additional irrigation development, including those due to the loss of hydropower generation capability. The changes predicted to occur can be classified as changes in (1) final demand, (2) output, or (3) exogenously determined prices. The short-run industry impacts stemming from each of these changes can be analyzed using input-output.

The flow of products described in an I-O transactions matrix can be represented mathematically for an n industrial sector economy as follows:

$$AX + F = X \text{ (or } F = (I - A)X) \qquad (1)$$

where

A = an (n × n) matrix of technical coefficients;
X = an (n × 1) gross output vector;
F = an (n × 1) final demand vector.

Conventional logic treats F as a vector of exogenous variables. With F given, and constant technical coefficients assumed, values of endogenous outputs can be estimated as $X = (I - A)^{-1}F$. Since the system is linear, it can also be used to relate changes in F,(ΔF), to changes in X,(ΔX), as

$$\Delta X = (I - A)^{-1}\Delta F. \qquad (2)$$

McKusick *et al.* explored the use of input-output for estimating regional development project impacts where the initial effects of the project were to increase capacity for output, and where certain assumptions could be made concerning use of the additional output. Essentially, the conventional classification of X as endogenous and F as exogenous is set aside, but the structure above, or the equivalent one

$$(I - A)\Delta X = \Delta F, \qquad (2')$$

is retained and imposed as a way of ensuring consistency in the accounting of estimated output, interindustry flows, and fixed demand changes arising from implementation of a project.

Their approach may be generalized by regarding the basic structure in (2) or (2′) as merely n equations in 2n variables (ΔX_i and ΔF_i, i = 1, 2, . . . , n) which must be satisfied after the change in economic activity that is contemplated. Assumptions regarding initial impacts may be stated in terms of n consistent independent linear conditions on $\Delta X_i + \Delta F_i$. These n conditions are appended to the basic structure in (2), permitting a solution for all 2n variables as measures of the final impacts of the change in economic activity that is contemplated. The simplest conditions to impose are those that merely set $\Delta X_i = 0$ and $\Delta F_i = 0$ for sectors which are unaffected by the activity change, but the approach is much more general than this and permits substantial flexibility in evaluating realistic scenarios. The requirement that the conditions must be consistent and linearly independent also has the advantage of implicitly defining bounds on the applicability of the approach.

Lee, Blakeslee, and Butcher provided an analogous framework for analyzing exogenous price changes in conjunction with changes in final demand. The I-O methodology used by Lee *et al.* to assess price change impacts is based on the simultaneous solution of three equations that describe the transactions matrix embodied in equation (2), with input and output prices implicit to equation (2) being explicitly modeled. To calculate changes in output, total income, and residual income due to exogenous price changes, all prices and final demands are indexed, a procedure that simplifies computation and eliminates the necessity of knowing base-period prices explicitly; it is only necessary to know by what percentage prices change from the base period. Using this method known as the "constant dollar" method,[3] the following equations were developed:

$$D_{\Delta p}(I - A)X - CY = D_{\Delta p}D_{\Delta t}T^0 \quad (3)$$
$$Y = R\ell' + \Delta P_w WX + Y_a \quad (4)$$
$$R = [\ell D_{\Delta p}(I - A) - \Delta P_w W - \ell D_{\Delta pm}M]D_x \quad (5)$$

where

$D_{\Delta p}$ = an $(n \times n)$ diagonal matrix with indexed prices, (P_i/P_i^0), on the diagonal, where P_i^0 is a base period price and P_i the new price,
C = an $(n \times 1)$ vector of marginal propensities to consume,
Y = total income (a scalar),
T^0 = an $(n \times 1)$ vector of base period final demands,
$D_{\Delta t}$ = an $(n \times n)$ diagonal matrix with indexed final demands, (T_i/T_i^0), on the diagonal,
R = a $(1 \times n)$ residual income vector,
ℓ = a $(1 \times n)$ vector of ones,
ΔP_w = P_w/P_w^0 (a scalar),
W = a $(1 \times n)$ labor requirements coefficient vector;
Y_a = autonomous income (a scalar),
$D_{\Delta pm}$ = an $(n \times n)$ diagonal matrix with indexed import prices, (P_{mi}/P_{mi}^0), on the diagonal,
M = an $(n \times n)$ matrix of import coefficients,
D_x = an $(n \times n)$ diagonal matrix of sector outputs.[4]

Equation (3) specifies that total output by sector ($D_{\Delta p}X$), minus interindustry sales ($D_{\Delta p}AX$) and interpersonal consumption expenditures (CY)[5] is equal to exogenous final demand ($D_{\Delta p}D_{\Delta t}T^0$). Equation (3) is analogous to equation (1) except that the prices are specified explicitly and household consumption is modeled as a function of total income.

Since total aggregate income is, in turn, a function of output, equations (4) and (5) become necessary to ensure consistency. Equation (4) defines total income (Y) as the sum of three components: (1) residual income ($R\ell'$), (2) total wages paid ($\Delta P_w WX$), and (3) autonomous income (Y_a). Total wages paid are assumed to be proportional to output, and autonomous income, all income payments made to households from outside the economy being modeled,[6] is determined exogenously. Residual income is determined by

[3] Lee *et al.* present a detailed discussion of this methodology, as do Bezdek and Wendling.

[4] Note that $D_x \ell' = X$.

[5] Although the consumption function specification used here differs from the traditional Keynesian consumption function which includes an intercept term, it is consistent with the I-O specification of household consumption. Future I-O modeling efforts however, may be aimed at incorporating an intercept term to improve the realism of I-O.

[6] For example, social security payments by the federal government represent one example of "autonomous income" for a state or regional economy in the U.S.

equation (5). Since residual income includes proprietor's income, rent, dividends, and interest paid, with "rent" and "dividends" including all returns to fixed factors of production (whether actually paid to factor owners or not), the residual income accruing to each industrial sector is defined as the gross income earned in that industry minus costs for nonlabor variable inputs, wages paid, and imported inputs.

When solved simultaneously by substitution, the above equations can be used to assess the output and income changes stemming from simultaneous changes in the final demand matrix ($D_{\Delta t}$) and prices: prices for imported inputs ($D_{\Delta pm}$), internal inputs and outputs ($D_{\Delta p}$), and labor (ΔP_w).

The effects stemming from changes in the wholesale price of electricity will be assessed in this framework, since additional irrigation reduces low-cost hydropower production and increases the need for high-cost thermal generation to meet energy demands. New irrigation will also result in increased primary agricultural output, the value of which can be measured as a function of the crops produced, the associated yields, and the output price. If changes in the quantities of primary agricultural output produced in the state are modeled as changes in final demand of the same magnitudes, the amount of primary agricultural production resulting from new irrigation will be overestimated, due to the indirect impacts stemming from increased final demand. Therefore, for this study, a procedure was used that makes use of the method described in the discussion of equations (2) and (2′) above. In addition, the framework developed by Lee *et al.* was further adapted to accommodate nonzero intrasector transactions rather than assuming them to be zero as in the original formulation.

The presence of nonzero intrasector transactions changes the model only by the treatment of intrahousehold transactions. The inclusion of intrahousehold transactions was readily accomplished by including in the income equation a new term (KY) representing the value of intrahousehold transactions. Thus, equation (4) was redefined as follows:

$$Y = R\ell' + \Delta P_w WX + Y_a + KY \qquad (4')$$

or

$$Y = \frac{1}{1 - K}(R\ell' + \Delta P_w WX + Y_a). \qquad (4'')$$

To accommodate output restrictions in addition to changes in final demand and exogenous prices, the simultaneous equations used to analyze exogenous price changes were partitioned into two subsets: (1) those I-O sectors for which gross output changes are restricted to some predetermined level, and (2) the remaining I-O sectors for which changes in final demand are known, and in many cases may equal zero. Each matrix or vector was partitioned to separate the k industries for which gross output changes are known.[7] By solving the partitioned matrices simultaneously, short run changes in sectoral gross output levels, total income, and residual income can be estimated even when several gross output, final demand, and price changes are occurring simultaneously in an economy. This methodology was used to measure the economic impacts of simultaneous increases in agricultural output production and electricity rates due to additional irrigation development.

Empirical Analysis

The input-output transactions matrix developed by Bourque and Conway for the 1972 Washington State economy was used as the base. Since this study addresses changes that may occur in the next decade, the transactions matrix was first up-

[7] For a discussion of the partitioning of equations (3), (4′), and (5) and the mathematics involved, refer to Findeis.

dated to reflect changes that have occurred or are predicted to occur over time in the Washington economy.[8] The RAS procedure was used to adjust the original technical coefficients, a_{ij}, to be consistent with future forecasts for the year chosen for analysis, 1985.[9]

After updating, the electric utilities sector was disaggregated into two sectors: (1) electricity generation, and (2) electricity transmission and distribution. This disaggregation allowed more accurate assessment of the effects of changing electricity generation costs due to additional irrigation development on rates charged to different power consumer classes. If the ratio of generation costs to distribution costs was identical for all classes of power consumers, the impacts of an exogenous price change could be assessed by increasing the delivered price of electricity by the same percentage for residential, commercial, and industrial consumers. However, different types of power consumers face blended electricity prices that are based on different generation/distribution cost ratios. Since the wholesale cost of electricity was assumed to be the same for all power consumers with differences in retail rates among consumer classes reflecting differences in distribution and transmission costs, it was possible to assess the impact of an exogenous price change in the electric generation sector only. The methodology described for assessing the effects of an exogenous price change was used to evaluate the effect of a change in the generated or wholesale price of electricity.

Additionally, the 51 industry 1972 model was aggregated to 33 industries with the household sector being the thirty-fourth "sector" in the Type II model. The agricultural and energy sectors were not aggregated, since changes in these sectors were the focus of this study. The other modification made to the I-O transactions matrix involved a reestimation of the cost of imported inputs used in the electricity generation sector. Since thermal power facilities rely more heavily on imported inputs (e.g., equipment and fuel) than do past generation systems in Washington, the import technical coefficient for this sector was increased with a corresponding decrease in the value-created coefficient.

The output, employment, labor income, and residual income impacts of irrigation development under each of the two future scenarios were estimated for both projects combined. Under Scenario I initial output changes were assumed in the field and seed crop sector and in the vegetables and fruits sector, while under Scenario II output increases were assumed to initially affect the following industries: field and seed crops, vegetables and fruits, livestock, canning and preserving, meat products, and dairy products. To isolate the effects of electricity rate changes, both scenarios were analyzed with and without changes in electricity prices resulting from additional irrigation development. The results are presented first without the electricity price change and then with the price change considered.

Aggregate Impact Assessment

When the statewide impacts resulting from increases in agricultural production are assessed without deducting the effects of new irrigation on electricity rates, irrigation stimulates statewide economic development. For example, under Scenario I real gross output increased by $435

[8] Projections of gross output changes were made on the basis of projections developed by Wilkins, Ley and Butcher, Bonneville Power Administration, and O'Rourke.

[9] The RAS procedure is a biproportional adjustment of an existing technology matrix. The existing A matrix is premultiplied by a diagonal matrix R and post multiplied by a diagonal matrix S such that RAS = A* or $r_i a_{ij} s_j = a^*_{ij}$. The procedure normally requires that the updated technology matrix be rebalanced after the adjustment.

TABLE 1. Statewide Impacts of Irrigated Development without Increasing Electricity Rates Considered.

Annual Impact[a]	Scenario I (Short Term)	Scenario II (Long Term)
Aggregate Output (Million Dollars)	435	1,187
Total Income[b] (Million Dollars)	323	634
Residual (Value-Created) Income (Million Dollars)	199	353
Labor Income (Million Dollars)	102	238
Job Opportunities[c] (Number of Jobs)	24,820	45,640

[a] 1972 dollars.
[b] Changes in total income will exceed the estimated changes in residual income plus labor income due to the feedback effects of intrahousehold transactions.
[c] Including proprietorships.

TABLE 2. Statewide Impacts of Irrigation Development with Increasing Electricity Rates Considered.

Annual Impact[a]	Scenario I (Short Term)	Scenario II (Long Term)
Aggregate Output (Million Dollars)	377	1,122
Total Income[b] (Million Dollars)	242	460
Residual (Value-Created) Income (Million Dollars)	138	209
Labor Income (Million Dollars)	86	220
Job Opportunities[c] (Number of Jobs)	22,640	43,130

[a] 1972 dollars.
[b] Changes in total income will exceed the estimated changes in residual income plus labor income due to the feedback effects of intrahousehold transactions.
[c] Including proprietorships.

million, employment by 24,820 jobs, labor income by $102 million, and residual income by $199 million annually. As shown in Table 1, gains under Scenario II in which forward linkages to the livestock, dairy, meat products, and canning and preserving sectors are modeled were much greater.

However, the quantity of electricity used and lost as a result of this additional economic activity is significant: 9,438 kwh per acre in the EHP, and 7,890 kwh per acre in the HHH. Since the energy used and lost will be replaced from higher-cost energy sources, higher electricity rates which have a depressing effect on statewide economic activity will result. Since most of the nonlabor inputs used to construct nuclear generation facilities are imported into the state, most of the increase in power gross revenues resulting from higher electricity rates is exported. Therefore, the increased utility rates reduce statewide output, employment, and income from the estimates in Table 1.

The estimated statewide impacts of irrigation development with higher electricity rates considered are shown in Table 2. Despite the adverse economic effects of higher electricity rates, the net impact of irrigation was found to be positive to statewide economic development. As shown in Table 2, when the impacts of higher electricity rates and increased agricultural production are simultaneously measured, total state output increased by $1,122 million, employment by 43,130 jobs, labor income by $220 million, and residual income earnings by $209 million under Scenario II. The effect of increased power rates was to reduce employment by 2,510 jobs and total income by $174 million from the levels attributed to irrigation when changes in electricity rates were not considered.

Distributional Implications

Although the net effects of additional development in Washington are positive, the aggregate output, income, and employment impact estimates fail to provide an indication of the distributional implications of development and do not reflect the higher cost of living resulting from higher electricity rates. As energy prices increase, the cost of living will increase in the state. For example, if both projects are developed under a Scenario II pattern, all residential electricity customers will pay

TABLE 3. Residual Income Losses Due to Additional Development under Scenario II.

Industry	Annual Residual Income Loss[a] ($1,000)
Aluminum	−18,344
Mining	−603
Wood Products	−1,926
Pulp and Paper	−2,158
Glass, Cement, Stone, and Clay	−360
Iron and Steel	−745
Other Nonferrous Metals	−85
Aerospace	−2,090

[a] 1972 dollars.

an additional $11.36 (1972 prices) per person annually on the average to maintain current electricity consumption levels, while not all households will benefit. Those households associated with agriculture will be the primary beneficiaries of new development.

Second, several important industries, most notably the aluminum industry, will experience absolute declines in residual income earnings. Sectors experiencing only a small decrease in residual income relative to total output are relatively immune to changes in electricity rates, and irrigation development will have little impact on these industries. However, industries relying heavily on electricity as an input may be significantly affected by higher rates. Such industries will experience short-run declines in residual income and will, in most cases, find it necessary to pass along price increases to consumers, adjust their production processes over time, or accept lower rates of return on fixed capital.

By examining changes in residual income earnings on an industry-by-industry basis, the "gainers" and "losers" of irrigation development were identified. If both projects are initiated under Scenario II, residual income accruing to the agricultural production and processing sectors will increase by $147 million, while earnings in the transportation services, trade, and services sectors will increase by $70 million. These sectors are the principal "gainers" from irrigation.

The remaining sectors of the economy would experience an absolute residual income loss. These industries are the "losers" from development. Unlike the "gainers" which tend to be concentrated in agriculture, the "losers" are diverse, with the negative impacts spread throughout the Washington economy. Since the major source of negative effects are electricity rate increases that are needed to recoup the costs of power replacements, the energy-intensive industries and particularly the aluminum industry, will lose the most if irrigation is undertaken. If development of both projects is initiated, the aluminum industry could lose as much as $18 million per year in residual income earnings under Scenario II. As shown in Table 3, absolute residual income losses will also occur in mining, wood products, pulp and paper, glass, cement, stone and clay, iron and steel, other nonferrous metals, and aerospace, in addition to aluminum. These industries have traditionally been important to the Washington economy, producing almost 30 percent of all output in the state.

Changes in Return on Stockholder Equity

To sharpen the focus on the secondary impacts of irrigation development, changes in return to equity that might result from the development activity for selected sectors of the economy were estimated. The ratio of residual income to total sales in a baseline solution was deducted from a like ratio for the Scenario II solution with electricity price changes, to provide an estimate of the change in residual income per unit of sales for a sector. This number was multiplied by the 1980 sales per equity ratio for specific sectors to provide an estimate of the change in return per unit of equity. The results for six selected sectors are shown in Table 4.

Of those sectors for which changes in returns to equity capital were estimated, aluminum, pulp and paper, and aerospace experienced declines in residual income due to irrigation development. These sectors were also shown to derive a reduction in the return to stockholder equity. It was estimated that the aluminum industry would experience nearly a 40 percent decline in the industry's return to equity. The declines for the aerospace and pulp and paper sectors were not as large, but, nevertheless, negative.

The chemical industry and the canning and preserving sector were shown to have higher residual income earnings coupled with declining return to equity ratios as a result of increasing energy costs. Perhaps the most interesting feature of Table 4 is the significant decline in return on equity for the canning and preserving sector. This industry had a large increase in employment and residual income resulting from irrigation development. However, the large associated increase in sales was accomplished by a decline in product price which, in combination with higher electricity costs, caused the return on equity to decrease sharply. Only the beverage sector, of those shown in Table 4, had both an increase in residual income and a higher return on equity. In the latter case, the decrease in the cost of grains to the brewing industry more than offset the increases in electricity costs resulting from irrigation development.

These estimated impacts indicate that the effects of new irrigation might be less desirable than only the employment and income data would show. In fact, the input-output results by themselves provide little guidance regarding the net benefits of development activity. The model results only serve to indicate what the general change in economic activity will be, not whether it is good or bad. It is shown that profits could decrease in several industries. Such industries would be reluctant to expand capacity through capital investment if that result was expected. It would be difficult to generate an incentive for subsidizing the primary development of irrigation among other sectors of the state economy under these conditions.

TABLE 4. Estimated Changes in Returns to Capital Equity in Selected Industries Resulting from Irrigation Development.

Industrial Sector	Return on Stockholder Equity—1980[a] (Percent)	Changes in Return on Stockholder Equity—1980 (Percent)
Beverages	15.60	.60
Food Canning and Preserving	14.50	−15.66
Aluminum	12.90	−4.83
Pulp and Paper	12.80	−0.59
Aerospace	16.20	−0.28
Chemicals	13.90	−1.10

[a] Source: U.S. Bureau of Census. Statistical Abstract of the United States, 1981. Table 935.

Conclusions

Although the results of this study show that new jobs would be created and more resources employed as a result of irrigation development, it would be naive and premature to conclude that irrigation development in either project should be undertaken. It is anticipated that at least some of the additional wage and salary workers employed would have an opportunity cost greater than zero. To more accurately assess the secondary benefits of irrigation, the opportunity cost of these workers and other factors should be determined and deducted from the benefits attributed to irrigation development.

Perhaps more important, input-output is an appropriate methodology for measuring the secondary impacts of irrigation development but does not provide measurements of the fixed costs associated with elevated levels of economic activity. Even if it is assumed that all industries prior to development are "profitable," it is shown that this profitability may be eroded by increased energy costs, investment costs for additional production, or decreases in commodity prices. In this study, higher electricity rates due to irrigation development depressed residual income earnings in Washington by approximately $144 million under Scenario II, causing the rate of return earned on fixed capital to decrease in most industries. As earnings are depressed it becomes questionable whether profitability will be maintained in all industries, especially in industries experiencing absolute residual income losses. Future research should concentrate more heavily on measuring the fixed costs associated with expansion, so that better comparisons of residual earnings to fixed costs can be made.

This analysis has focused only on the impacts of irrigation development in Washington State. However, approximately one-half of the negative impact from higher electricity rates due to additional irrigation in Washington will fall within the states of Idaho and Oregon. The demonstrated changes in returns to capital investment could negatively affect industries in neighboring states.

If subsidies for development are forthcoming from outside the state, it may be in the interest of the state to encourage such development. In this case, most of the benefits occur within Washington while much of the costs, including subsidies for development, will fall outside the state. However, if subsidies must be provided from within the state, there is no assurance that sufficient additional profits can be generated in other sectors to subsidize irrigation development. The subsidies to irrigation coupled with higher electricity rates may indirectly curtail other sectors, partly offsetting the economic stimulus from irrigation. As electric energy becomes scarcer, public investment in other investment alternatives may be more beneficial to long-run economic growth in the Northwest than energy-intensive irrigated agriculture. Irrigation development will likely continue to be controversial, with ultimate decisions about growth being settled in the political arena rather than on the basis of economics.

This study did not consider one major feature of current federal policy regarding USBR irrigation projects. States must now provide approximately 20 percent of the total capital subsidy for such projects. In this case, Washington State will have to contribute about $1,000 per acre to the construction cost subsidy of the East High Project. This cost, to be paid from state general revenues, will reduce household disposable income by a like amount. This state level subsidy would significantly reduce estimates of secondary income and employment from those shown in this analysis and cause additional concern about the desirability of the project.

References

Bezdek, R. H. and R. M. Wendling. "Current and Constant Dollar Input-Output Forecasts for the U.S. Economy." Paper presented at the American Statistical Association, St. Louis, Missouri, 1974.

Bonneville Power Administration. "Washington: Population, Employment and Households to 2000." Portland, Oregon, July, 1979.

Bourque, P. J. and R. S. Conway, Jr. "The Washington Input-Output Study." Graduate School of Business Administration, University of Washington, Seattle, Washington, June, 1977.

Findeis, J. L. and N. K. Whittlesey. "Competition between Irrigation and Hydropower Water Use in Washington State." State of Washington Water Research Center, Report 44, June, 1982.

Findeis, J. L. "Input-Output Analysis: A Methodology for Assessing Short Run Changes in Exogenous Prices, Output, and Final Demand." A.E.&R.S. 165, Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University, May, 1983.

Hastay, M., J. A. Crutchfield, B. W. Mar, G. Brown, Jr., M. C. Bell, R. A. Sutherland, E. P. Richey, and M. C. Jensen. "The Columbia River as a Resource." State of Washington Water Research Center, Report 5A, Washington State University, Pullman, Washington, June, 1971.

Lee, G., L. L. Blakeslee, and W. R. Butcher. "Effects of Exogenous Price Changes on a Regional Economy: An Input-Output Analysis." *International Regional Science Review,* 2(1977):1 15–27.

Ley, R. and W. Butcher. "Guidelines for a Northwest Energy Policy, Phase I, Report on Energy Supplies, Uses and Energy Surplus or Shortfall, Appendix B: Population for the Pacific Northwest." Washington State University, Pullman, Washington, June, 1974.

McKusick, R., N. Bills, R. Clark, C. Jones, R. Niehaus, C. Palmer, S. Stripe, J. Wilkins, and L. Zygadio. "Regional Development and Plan Evaluation: The use of Input-Output Analysis." U.S. Department of Agriculture, Agricultural Handbook No. 530, 1978.

O'Rourke, A. D. "Projections of Market Demand for Pacific Northwest Agriculture to the Year 2000." Northwest Agricultural Development Project Report No. 7. Pullman, Washington, January, 1980.

U.S. Army Corps of Engineers. "Columbia Basin Water Withdrawal Environmental Review, Executive Summary and Technical Appendices." Portland District, Portland, Oregon, May, 1980.

U.S. Bureau of Census. *Statistical Abstract of the United States,* 1981.

Wharton, R. B. "The Hydropower Cost of Irrigation Development Fisheries Enhancement in Basin." Unpublished M.A. thesis, Washington State University, Pullman, Washington, 1980.

Whittlesey, N. K., J. R. Buteau, W. R. Butcher, and D. Walker. "Energy Trade-offs and Economic Feasibility of Irrigation Development in the Pacific Northwest." College of Agriculture Research Center, Washington State University, Pullman, Washington, Bull. 0896, 1981.

Wilkins, J. "Selected Effects of Additional Irrigation in the Columbia Basin: A Multiregional Analysis." Unpublished Ph.D. Dissertation, Oregon State University, Corvallis, Oregon, February, 1979.