Including the Economic Impact of Cost Paying in Regional Input-Output Analysis

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Traditional input-output analysis is used to determine indirect and induced benefits
resulting from spending on a particular project. Emphasis has been on positive
impacts to the economy in question, usually ignoring the related costs of paying for
the project. Input-output was used in this study to see if the negative impacts brought
about by payments for a project were significant. Negative impacts were found to give
rise to significant indirect and induced negative impacts on the economy suggesting
that negative impacts be included as a standard feature in input-output analysis.

Key words: input-output, negative impact, value added.

Input-output (I-O) methodology is often used
for predictions of local or regional economic
changes that are expected if a project is un-
dertaken. I-O is a useful tool because it pro-
vides not only an accounting of a project's di-
rect effects but also provides estimates of
indirect effects and induced changes through-
out the regional economy. Indirect and in-
duced effects are not included in the benefit-
cost (B-C) analysis that all federal projects must
undergo prior to funding. B-C compares only
direct costs with direct benefits. If resources
that would otherwise be unemployed are used
as a result of a project, a direct "employment
benefit" may be credited. However, indirect
or secondary effects such as might be predicted
by I-O analysis may be included only in a "re-
gional development" accounting or as part of
a socioeconomic impact assessment.

When I-O analysis or other methods are used
to predict a project's economic impacts, the
focus is usually only on the positive indirect
and induced effects. An example would be ex-
amining increased economic activity and em-
ployment due to the construction of the project
and due to the increased production or de-
creased damages after the project is in opera-

tion (Charles Rivers Associates; Johnson and
Bennett). Negative impacts also may occur be-
cause of obligations to repay the costs of a
project, through taxes or other means, and due
to possible adverse effects on incomes of other
parties.

If the project's costs will be borne entirely
by economic entities located outside the im-
pact study area, then it is correct to assume
that there will be no negative repayment effects
felt locally. However, it appears that economic
impact analyses generally ignore negative cost-
bearing effects without consideration of wheth-
er they will occur within or outside of the study
area. Some studies have incorporated a few
negative impacts in their analysis but ignored
other negative influences. Conrad and Hen-
seler-Unger found the differences in the price
of electricity between nuclear and coal gener-
ating plants could affect economic develop-
ment. They did not investigate the impact on
development of taxing to pay for plants that
may differ in costs to build. Findeis and Whit-
tlesey included changes in electrical rates
brought about by diverting water from hydro-
electric generation to irrigation. They did not
include in their discussion any other negative
economic impacts caused by an increase in
taxes.

The study reported here estimated the eco-
nomic impact, including both positive and
negative effects, of a proposed expansion of

irrigation in the Columbia Basin Project located in central Washington. An I-O model for the state of Washington and a model for the three-county project area were used to predict increased economic activity due to spending for construction and operating costs and from increased sales of agricultural products and processing services. The negative impacts of the state and local shares of the substantial construction cost repayment obligation, the additional costs that electricity users would incur, and the loss of income due to price declines for products expected to be produced in large volume on the project were included in the state or local analysis as appropriate. The inclusion of negative effects contrasts with the approach used in a state-funded study of the project's predicted socioeconomic impacts (Economic and Engineering Services).

The Columbia Basin Project, which has about 600,000 acres of land under irrigation, was developed by the U.S. Bureau of Reclamation mostly during the 1950s and 1960s. In the early 1980s, it was proposed that the state of Washington issue state bonds to pay some 15–20% of the construction costs required for irrigating an additional 538,000 acres. The remainder of the costs would be paid initially by the federal government and then recovered out of payments made by the benefiting irrigators and the regional federal power system. Other cost burdens to regional power users would arise from the project's consumption of power and the loss of hydropower generating capability.

The I-O Model

The basis for I-O analysis is the interindustry transactions matrix. A direct requirements matrix (A), showing the direct input requirements per dollar of output, is derived from the interindustry transactions matrix by dividing interindustry purchases of each sector by the output of the sector (Miernyk; or Bourque and Conway). For this study, it was assumed that households were endogenous to the model (a type II model) as is most often the case for regional analysis.

The interdependence coefficients show direct plus indirect and induced changes in the economy necessary to support an additional dollar's worth of delivery to final demand. The matrix of interdependence coefficients is found

by first subtracting the direct requirements matrix (A) from an identity matrix of the same order to get an (I-A) matrix and then inverting (I-A).

If F is a column matrix of order n whose entries are the final demands for sectors one through n, and if X is the column matrix of order one of industry output, then the development of the interdependence coefficient matrix can be written as:

(1) $(F) = (I\text{-}A)(X)$

or:

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

The interdependence coefficients matrix $(I\text{-}A)^{-1}$ of (2) is used in predicting changes in output as a result of changes in delivery to final demand. Each element in the $(I\text{-}A)^{-1}$, known as C_{ij}, is interpreted as being the direct, indirect, and induced output required from regional industry i per dollar of final demand delivered from industry j. The total change from a change of one unit in final demand for output of the j industries is given by the row sum $\sum_j C_{ij}$.

Value added, which consists of wages, salaries, rent, interest, business profits, depreciation, and indirect business taxes, is a measure of impact for which I-O analysis is often used. Value-added multipliers can be calculated by:

(3) $\begin{matrix} (VAM) = & (v) & (I - A)^{-1} \\ (1 \times n) & (1 \times n) & (n \times n) \end{matrix}$

where (VAM) is the vector of value-added multipliers for each industry, and (v) is the vector of value-added coefficients (a transpose of the value-added row of the direct requirements matrix). Since value-added multipliers give total changes in value added per dollar of final demand for each sector, a vector of changes in final demands is necessary for calculating the change in value added associated with a complex project. The total value-added change is:

(4) $\begin{matrix} (TVA) = & (VAM) & (F) \\ (1 \times 1) & (1 \times n) & (n \times 1) \end{matrix}$

where (TVA) is a scalar showing total change in value added and (F) is the vector showing expected change in delivery to final demand. Table 1 shows the most important multipliers calculated with the I-O model.

Estimating final demand changes, (F), thus becomes an important step in economic analysis. For an irrigation project, final demand

Table 1. Selected Value-Added Multipliers

Sector Name	Washington State	Project Area
Field & Seed	1.62	1.28
Veg. & Fruit	1.90	1.52
Livestock	1.46	1.54
Food Processing	1.43	1.01
Transportation	1.65	1.31
Construction	1.29	0.86
Value Added	2.21	1.85

consists, in part, of increased agricultural output and, in part, of construction of the irrigation system. The direct benefits to an area from increased crop production and money spent on construction are estimated, the result being termed final demand. When final demand is multiplied by the value-added multiplier, the impact upon the entire economy of the area is found. The multipliers show what happens to the economy after the project money has been spread throughout the area. For instance, money spent on the construction of a road will be used to purchase direct items such as labor, machinery, equipment, and material. This money paid to contractors will be spent by the contractors to buy new equipment, supplies, and material from their suppliers. These industries in turn buy from others until the impact is felt throughout the region.

New industries, resource developments, and public projects are widely prized not only for their payrolls and tax revenues but also for their indirect stimulus to other sectors of the state or local economy. It has become standard for estimates of these secondary economic effects to be provided when the discussion comes to questions of local or state contributions required to recruit industries, establish the economic feasibility of resource developments, or gain federal funding for local projects.

If all of the money needed for a project came from the federal government or other extraregional sources, the positive impacts of new jobs and new income for the area might provide an accurate prediction of economic change brought about by the project. Most I-O studies have taken such an approach to predicting economic impacts (Charles Rivers Associates; Economic and Engineering Services; Findeis and Whittlesey). However, when tax money or other reductions to incomes from inside the area are used to pay for a public project, negative effects will occur. Money spent on taxes

is money not spent for consumer goods. Local merchants will feel the consequences of their customers having fewer dollars to spend. Reduced consumer spending, due to a reduction in disposable income resulting from increased taxes or other required local contributions to a project, constitute a direct negative impact on the economy.

The reductions in consumer spending that follow from paying project costs have a negative effect on the local economy that is identical in nature but opposite in direction to the positive effects of project spending and economic expansion. Thus, using multiplier analysis, the indirect impacts of these negative direct effects also can be estimated. It is appropriate to ignore these negative impacts only if project costs are paid for entirely from outside the region. If money is used from within the project area to pay for the project or if there are locally borne opportunity costs, the negative impacts cannot be ignored.

This study estimated the indirect economic impacts from a proposed federal irrigation project in the Columbia River Basin of Washington State. Positive impacts upon the state's economy were estimated to come from the increased agricultural output arising from bringing irrigation water to a fertile but arid farming area and from money spent on construction of the irrigation system itself. Negative impacts were calculated for required local repayment of project costs, for opportunity costs of water and energy diverted from other purposes to project use, and for the economic rents lost due to agricultural product price declines.

Taxpayers would pay for a portion of the irrigation construction out of the taxes paid to state and national governments. Those farmers who would receive project water would be required to repay a portion of the construction cost. Consumers who purchase electricity from the Bonneville Power Administration (BPA) also would have to pay for a portion of the cost of constructing the irrigation system.

Further burdens would fall on electrical power customers in the area as a result of water being withdrawn from the Columbia River and used for irrigation. If this water had not been used for irrigation, it could have been used to produce additional electrical energy in the Columbia River hydroelectrical generation system. Four acre-feet of water would be withdrawn at Grand Coulee Dam per acre irrigated, with 2.56 acre-feet used in irrigation and 1.44

acre-feet returning to the Columbia River at McNary Dam (Butcher and Hamilton, p. 5-4). A conservative replacement cost of 28 mills/KWH was used, which approximates the cost to operate a coal generating plant (Bonneville Power Administration 1983). Electric utility customers would have to pay for replacement of this lost power.

Farmers in the area would experience a loss in revenue because the increased output on project land would work through the market system to cause a lowering of the price for locally grown crops. Revenue would fall for all farmers because of this price movement.

For this study, money taken from taxpayers and ratepayers to pay for project-related costs plus the farmers' reduced revenue were treated as reductions in disposable income. It is as if consumers experienced a loss in exogenous income. Most of this income loss was assumed to cause a decrease in consumption of Washington State products. Part of the lost income also reduced spending on items imported from outside the state. It was assumed that no change in savings occurred. To incorporate this impact into the I-O model, a decrease in delivery to final demand from the value-added (includes labor income) sector was assumed to occur. Through the multiplier process, the total impact on the state of this decrease was found.

Another final demand change would result because a portion of production of certain high-value crops would fall in areas outside the project. Apples, potatoes, and alfalfa were chosen as three typical high-value cash crops to be grown in the project area. Increased output on project acres was found to cause the market price of these three crops to fall. The decreased market price brought about by larger quantities of these crops would force those farmers with higher production costs or lower yields to switch from one of the high-value crops to a lower-value crop, chosen in this case to be wheat. Because of the productivity of the land and the relatively low cost of water in the project area, it was assumed that these higher-cost farmers produced outside the project area. They would not be able to profitably produce these crops after a fall in the price. The life of the project was 79 years for the purposes of this study. The change to wheat would occur over a period of time. The change would occur relatively quickly for hay producers but would take longer for producers of potatoes or apples.

This negative impact was treated as a reduction in delivery to final demand in the sector corresponding to the crop which was originally grown. Productivity and output changes were based on data provided by the U.S. Bureau of Reclamation.

In general, the process used to determine these changes was to first estimate the increased production of the crop in the newly irrigated area based on the cropping patterns and yields existing in the land already receiving irrigation water. The results of other studies were then used to get price changes and subsequent changes in other areas' output. Estimates of the price change for alfalfa relied on work done by El-Habbab. El-Habbab's structural model for determining harvested acres and hay price estimated the short-run price elasticity of demand to be $-.717$ with the price elasticity of supply to be .048. A study by Estes was used to make appropriate changes in the potato market. His study concluded the price elasticity of demand for potatoes to be $-.235$ and the price elasticity of supply to be .259. The price and quantity changes brought about for apples were estimated using the supply and demand equations as estimated by Baritelle. Actual farm operating costs came from Washington State Cooperative Extension Bulletins (Hinman, Tukey, and Hunter; Hinman, Wright, and Willett).

Consumers in Washington were not found to have an offsetting gain resulting from a decrease in commodity prices. Apples and potatoes are primarily exported for sale outside the state. A comparatively larger share of alfalfa is sold in state to dairy producers, and reduced dairy input prices could impact dairy consumers. These secondary impacts on dairy consumers were not calculated.

The creation of the transactions matrix is important for accurate output. For this study, the starting point was a 51-sector I-O model developed for Washington State by Bourque and Conway for 1972 using surveys and primary data. This model was updated to 1990 using data from the Bonneville Power Administration (1984) and the Northwest Agricultural Development Project. The actual updating was done by a computer procedure entitled NEWFLOW. The NEWFLOW program estimated the 1990 transactions matrix based on the existing 1972 matrix and estimates for 1990 interindustry sales and purchases. (NEWFLOW was supplied by J. Wilkens of the

Table 2. Positive and Negative Value-Added Impacts

Project Effects	($1 million 1982)		
	Total State Value Added	Project Area Value Added	Value Added Outside Project Area
Positive			
Ag Output	821	491	330
Construction	54	36	18
Total Positive	875	527	348
Negative			
Financing	21	4	17
Elect. Energy	5	0	5
Farm Related	295	18	227
Total Negative	321	22	299
Net (Pos − Neg)	554	505	49

Note: All amounts are 1982 dollars using levelized costs and benefits where $LC = PV[(r)(ltr)^t]/[(ltr)^{t-1}]$ and LC = levelized costs or benefits, PV = present value, r = 3% (assumed real interest rate), and t = 79 years (life of the project).

Bonneville Power Administration.) This 51-sector model was then condensed to a 33-sector model which kept the necessary detail in agricultural related industries but aggregated other industries where detail was not needed. For example, the industrial chemical sector and other chemical sector of the 51-sector model were combined to make one chemical sector in the 33-sector model.

The new 1990 Washington State I-O model was used as a base for constructing an I-O model for the portion of the state which was to receive irrigation water. A nonsurvey technique known as the Location-Quotient method (Schaffer and Chu) was chosen to construct this model. A 14-sector model was developed using the Location-Quotient method and data from the Washington State Department of Revenue.

The results of including negative economic inputs into an I-O analysis are shown in table 2. In that table, positive and negative value-added impacts were calculated for two regions. One of these regions was a three-county area (Adams, Franklin, and Grant counties) containing all of the farms which would receive water under the proposed irrigation project. The other region was Washington State outside the three-county area.

Two types of positive impacts are included in table 2. One shows how value added in-creases as a result of increased agricultural output, while the other shows how construction benefits the regions. Total positive value added was $875 million, of which about 60% occurred inside the project area. This is not surprising since the irrigation construction and increased crop production would occur within this area. Positive impacts would occur outside the region as the impacts of construction and expanded production spread throughout the state.

Three types of negative impacts are shown. One of these was finance charges which had to do with the impact of taxes being levied to pay for bond interest and debt retirement for the construction of the irrigation system. Electrical energy was the cost of replacing lost hydro-electrical power with more expensive thermal power. Hydroelectrical generation capacity is lowered as water is diverted to irrigation. The farm-related category shows losses to farmers outside the project area who would be forced to switch from high-value crops to lower-value crops such as wheat. This change was caused by project production lowering the price of high-value crops and forcing higher-cost producers to switch crops thus lowering their farm income. Total negative impacts to Washington State were $321 million. Residents of the project area bore only $22 million of these negative impacts which was just under 7% of the total.

Implications

Looking at the net impacts shows an important reason for including negative impacts in project analysis. Of the $554 million of net benefits, $505 million or 91% of the net benefits accrued to residents of the project area. This is in part because 60% of the benefits went to those inside the project area leaving 40% for those outside the area. The high proportion of costs borne by people living outside the project area leaves a major portion of the net benefits going to those in the three-county area receiving irrigation water. A traditional analysis, including only positive impacts, would show benefits more evenly split between those people living inside and outside the project area.

The results have political implications. A legislator living outside the project area who was shown an economic analysis of a proposed project which only included positive impacts might well favor the project if constituents in

his/her area would receive 40% of the positive impacts. The same legislator might come to a different conclusion if the economic analysis included both positive and negative impacts. Constituents outside the project would get 9% ($49 million out of $554 million) of the net benefits. The project then might be seen as a subsidy for those inside the project area instead of a proposal from which all residents of the state would benefit. This subsidy, or income transfer, might be considered inequitable depending upon the income levels in the two different regions.

The use of negative impacts may be even more important if projects are analyzed on a national level. The benefits would not change materially and would still go primarily to people living within the project region. Negative impacts on a national level would depend on the portion of the project financed by the federal government and thus paid for by taxpayers living in the rest of the country. These taxpayers would have reduced incomes as a result of taxes levied to pay for the irrigation system. Reduced incomes would lead to reduced spending and negative impacts would be felt throughout the country. Income reduction per person would be small, but in total the impact is significant. The result would be a higher percent of net benefits occurring to people living within the project area. Offsetting this would be an increase in consumer benefits from a decrease in commodity prices which on a national level will benefit national consumers more than Washington State consumers.

Projects should not be evaluated solely on information from I-O results. Results from the use of I-O do not look at the profitability of individual firms and do not include a comparison of direct benefits with direct costs. Both of these factors are important in the decision-making process.

Summary

Traditional input-output analysis focuses on benefits resulting from a particular project. In this study, a potential irrigation project in Washington State was studied to see if the costs of the project would result in significant negative economic impacts. The negative impacts were found to be significant, approximately 34% of the positive impacts. While the negative impacts were not larger than the positive ones, the inclusion of negative impacts is a significant addition to I-O analysis. On a theoretical level it is consistent to compare the direct, indirect, and induced costs with direct, indirect, and induced benefits.

On a practical level, legislators may find the additional information useful. Legislators from project and nonproject areas may favor a project when shown only positive I-O impacts. Nonproject legislators may react differently to an I-O analysis including costs. In this study, most benefits went to people living in the project area, while most costs were borne by people living outside the project area. In times of tight budgets, this recognition of an income transfer may not be politically acceptable.

Based on this information, future users of input-output analysis might well consider examining both positive and negative economic impacts.

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