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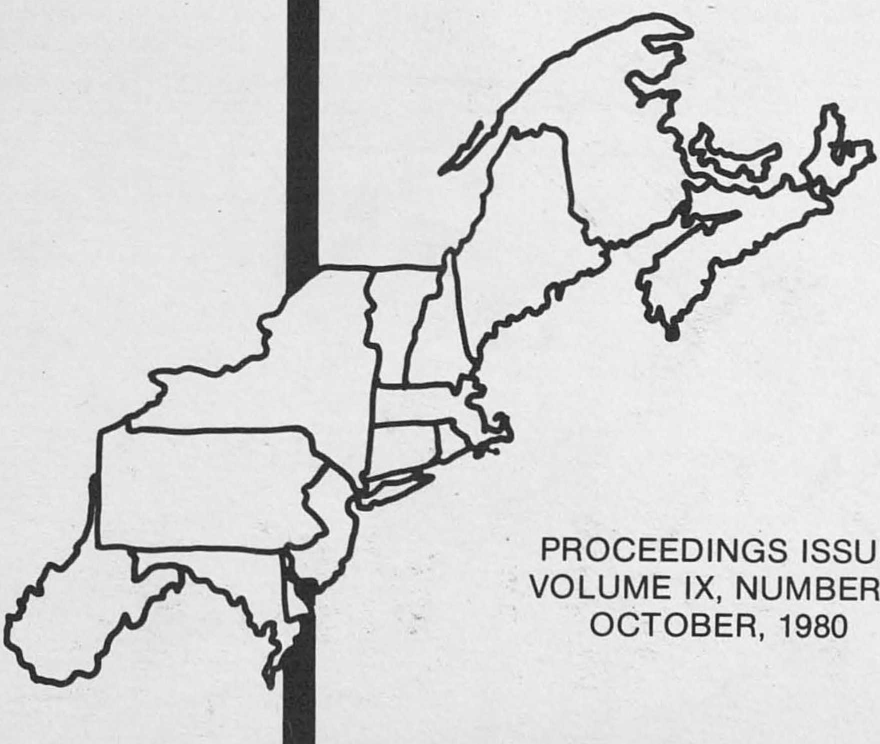

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INDIRECT EMPLOYMENT AND INCOME DISTRIBUTION IMPACTS OF INVESTMENT PROGRAMS

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INTRODUCTION

Private and public investment programs are often implemented without adequate knowledge of their employment or income distribution impacts. For example, although numerous studies have been done on the environmental and economic efficiency aspects of electricity generation alternatives, relatively little is known of who will benefit and by how much.

Distributional impacts need to be evaluated for several reasons. First, if these impacts are ignored, investment programs may be selected which have a perverse effect upon public programs which are designed to achieve a more equitable distribution of income or employment. Second, in choosing among alternative investment programs an awareness of the potential tradeoffs between economic efficiency and distribution is required.

Most studies of the distribution of the benefits and costs of investment programs have focused upon the distribution of *primary* benefits and costs. Examples include the analysis conducted by Haveman (1965); Freeman (1967); Bonnen (1968); Hohen, Robbins and Anschel (1980); Collins (1977); and by Infanger and Butcher (1974). Investment programs do, however, create indirect (secondary) benefits and costs. If full employment prevails, these indirect impacts should not be counted as efficiency effects from a national perspective. Indirect impacts do, however, have distributional implications which should be included in analysis of the distributional consequences of investment program alternatives. Yet, there has been little empirical analysis of the distribution of indirect impacts. (For a recent exception, see Thurow, 1980.)

This paper presents a methodology for evaluating the distribution, by income class and employment category, of the indirect effects of investment program alternatives. The methodology is then empirically implemented to evaluate, as a case study, the distributional impacts of the construction of a hypothetical nuclear power plant located in Massachusetts.

PROCEDURES

The methodology for estimating indirect distributional impacts was based upon a traditional input-output framework. A numerical example helps to elucidate the procedure used.

Assume a two sector economy with the hypothetical direct input-output coefficients displayed in Table 1.

The direct and indirect input-output coefficients are defined by:

$$[A] = \begin{bmatrix} .2 & .3 \\ .4 & .1 \end{bmatrix} \quad I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \quad [I - A] = \begin{bmatrix} .8 & -.3 \\ -.4 & .9 \end{bmatrix}$$

$$[I - A]^{-1} = \frac{1}{.6} \begin{bmatrix} .9 & .3 \\ .4 & .8 \end{bmatrix} = \begin{bmatrix} 1.5 & .5 \\ .67 & 1.34 \end{bmatrix}$$

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The elements of [A] (Table 1) indicate the direct impact of a $1.00 change in final demand. The direct and indirect impacts can be calculated by:

$$[X] = [I - A]^{-1} [Y]$$

where Y is the final demand. Thus, a $1.00 increase in Y_2 (the final demand of Sector II) will generate:

$$X = \begin{bmatrix} 1.5 & .5 \\ .67 & 1.34 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} .5 \\ 1.34 \end{bmatrix}$$

Table 1.
An Illustration of a Basic Input-Output Table

Industry Producing \ Industry Purchasing	I	II
I	.2	.3
II	.4	.1
Employee Compensation	.3	.4
Other Value Added	.1	.2
Total	1.0	1.0

That is, one dollar of new exogenous demand for the output of Sector II (Y_2) will cause the output of Sector I to grow by $.50 and that of Sector II to increase by $1.34. Value added will then change as shown in Table 2.

To derive the distribution of the change in employee compensation by income and employment classes, information of the distribution of employees in each economic sector by income and occupation class is required. Census data may be used for this purpose. The Census reports the distribution of employees by occupational categories for each economic sector for each state. For example, assume two employment categories, A and B, distributed as shown in Table 3.

The Census also reports the distribution of income for each occupational category. In the two sector case presented assume this distribution to be that shown in Table 4.

Assuming fixed coefficients and using the hypothetical data presented in Tables 1 through 4, the direct and indirect effects of a $1.00 increase in the final demand of Sector II will be distributed by employment and income classes as in Table 5.

EMPIRICAL IMPLEMENTATION

The situation chosen for empirical analysis was the construction of hypothetical 2300 Mw twin-unit nuclear power plant located in

Table 2.
Change in Value-Added Due to $1.00 Change in Final Demand for Sector II

	Sector I		Sector II		Total Change
Employee Compensation	(.3) (.5) =	$.15 (.4)	(1.34) =	$.54	$ .69
Other Value Added	(.1) (.5) =	.05 (.2)	(1.34) =	.27	.32
Total		$.20		$.81	$1.01

Massachusetts. The input-output model for the state of Massachusetts was formulated by George Treyz, *et al.*(1975; 1979). This model is a multiperiod macroeconomic policy model which consists of an input-output core and a system of simultaneous econometric equations (linked with the national economy) which yield employment by economic sector, wages, and prices due to a change in the economic activity at the state level.

Table 3.
Distribution of Employees by Occupational Category by Sector (Percent)

Occupational Category	Sector I	Sector II
Type A	20	30
Type B	80	70
Total	100	100

Table 4.
Distribution of Occupations by Income Classes (Percent)

Occupational Type	*Income Class* 1	2	3
A	20	30	50
B	50	10	40

Table 5.
Distribution of Direct and Indirect Impacts by Occupation and Income Classes

Distribution	*$ Direct*	*$ Indirect*	*$ Total*
Change in Employee Compensation			
Sector I	0	.15	.15M
Sector II	.40	.14	.54
Distribution of Compensation by Occupational Category			
Type A, Sector I	0	.030	.030
Type A, Sector II	.120	.042	.162
Type B, Sector I	0	.120	.120
Type B, Sector II	.280	.098	.378
Distribution by Income Class			
Class 1	.164	.1234	.2874
Class 2	.064	.0434	.1074
Class 3	.172	.1232	.2952

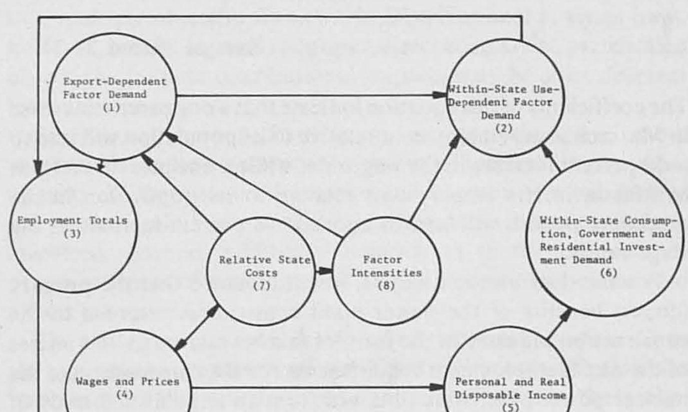
The important endogenous features of the model are shown in Figure 1. Exports (Sector 1) from the state depend on national and international demand, and on the relative advantage of the state as a location for the industry in question. In this model, changes in the costs of production in the state relative to the nation play a key role in determining business location. The second arrow pointing to Sector 1 indicates that relative factor intensity (e.g., capital/labor ratio) of production must also be known before export-dependent factor (input) demand can be derived from output demand. In this model, factor ratios are held constant because a fixed input production function is used.

Within-state use-dependent factor demand (Sector 2) also depends on factor intensity. In this sector, intermediate input demand for each industry is determined, based on relative input costs and the state input-output relationships embedded in this sector. Within-state final demand comes from the local demand Sector (6). Investment demand is derived from changes in capital stock demand. Total employment (Sector 3) is simply the sum of export and local-use-dependent employment.

Personal income (Sector 5) is made up of identities based on wage rates, employment, taxes, prices, property incomes and transfers. Local consumer demand (Sector 6) depends on real disposable income in the state. State and local government spending is based on real income and on trends in state and local government spending for the nation.

Relative state costs of production are determined (Sector 7) by equations that are based on a specific production function and on tax, capital, fuel, intermediate inputs and labor costs. The last sector (8) determines factor intensities of production based on a production function, relative factor costs and an assumed equality of marginal costs with marginal products, for each factor of production, when new capital purchases are made.

The principal sector of the model in this research is the labor supply and wage determination portion (Sector 4). All too many models of regional economies assume that there is an infinite supply of labor at the going wage. This is, a shift in labor demand is



Source: Treyz (1979)

FIGURE 1.
Endogenous Sectors

assumed to be fully reflected in increased employment without any effect on wages. This leads to an overstatement of the employment-creating potential of proposed investment projects.

To relax this assumption, the following equation was estimated to make population (a proxy for labor supply) an endogenous variable (Treyz, 1979):

$$L(N^n/N^u) = -2.06 + \underset{(2.04)}{.28}L(RW^m/RW^u)_{t-1} + \underset{(5.55)}{.43}L\{(E^m/N^m) \div (E^u/N^u)\} \quad (1)$$

$$R^2 = .98 \qquad D.W. = 3.6 \qquad \text{Sample Period 71-77}$$

where

(N^n/N^u) is the state population relative to the U.S. population

$(RW^m/RW^u)_{t-1}$ is the relative real wage in the state in the previous year and

$(E^m/N^m) \div (E^u/N^u)$ is the relative employment to population ratio in the state, L indicates a natural log function and numbers in parentheses are "t" values.

As noted by Treyz (1979), the coefficients in equation (1) can be interpreted as elasticities. The first elasticity of .28 indicates that a one percent increase in the real wage in Massachusetts relative to the real wage in the United States will lead to a .28 percent increase in Massachusetts population relative to what that population would have been if there had not been an increase in the relative Massachusetts wage. The .43 coefficient indicates that a one percent increase in Massachusetts employment relative to its population will lead to a .43 percent increase in Massachusetts population. That is to say, an increase in employment participation in Massachusetts will lead to an increase in Massachusetts population.

The wage determination equation was of the following form (Treyz, 1979):

$$L(W^m/W^u) = -.08 + \underset{(2.44)}{.59}L\{(E^m/N^m) \div (E^u/N^u)\} +$$

$$\underset{(2.05)}{.48}L\{(E^m/N^m) \div (E^u/N^u)\}_{t-1} \quad (2)$$

$$R^2 = .95 \qquad D.W. = 2.1 \qquad \text{Sample Period 71-77}$$

The coefficients of this equation indicate that a one percent increase in Massachusetts employment relative to its population will lead to a .59 percent increase in the wage rate, while a one percent increase in Massachusetts employment relative to its population in the preceding period, will lead to another .48 percent increase in the wage rate.

For the distribution analysis, it was assumed that the primary (direct) benefits of the power plant construction accrued to the construction industry in the form of salaries and wages. Estimates of the direct employment requirements for the construction of the nuclear power plant were obtained from an unpublished study of the Long Island Lighting Company Nuclear Plant (LILCO). These on-site construction labor and operation and maintenance (OM) requirements are presented in Table 6.

To evaluate the distribution of the direct effects of construction, the distribution of the construction labor force by occupational categories was obtained from the 1970 Census of the State of Massachusetts (Column 2 of Table 7). The direct employment resulting from the construction of the nuclear facility was then distributed by occupational categories (Column 3 of Table 7) according to the proportions in Column 2 of Table 7.

1970 Census data for the State of Massachusetts of the distribution of income by occupational classes for the construction sector was then used to distribute the direct employment effects of plant construction by income classes (Table 8). The direct construction effects were estimated to be distributed by income classes as shown in the total row of Table 8. From 1970 Census data, the distribution of income in the state prior to plant construction was 40, 39, 14 and 7 percent for the \$1-4999, \$5,000 to 9,999, \$10,000 to 14,999 and \$15,000 and over classes respectively. Therefore, the distribution of the direct effects are estimated to be towards the upper income classes by comparison with the distribution in the state. This occurs because the majority of construction workers are classified as craftsmen (Table 7) whose earnings place them in the upper income classes (Table 8).

Table 6.
Direct Labor Requirements for Construction of a 2300 Mw Twin-Unit Nuclear Power Plant

Year	Construction Workers	O & M Workers	Total
1978	600	—	600
1979	1126	—	1126
1980	2202	—	2202
1981	2905	—	2905
1982	3244	—	3244
1983	2065	100*	2165
1984	1057	100*	1157
1985	651	250	592
1986	—	250	250
⋮		⋮	⋮
1990	—	250	250

*For Unit 1 only.
Source: Derived from LILCO data, 1975.

Table 7.
Distribution of Construction Labor Requirements by Occupational Category

Occupational Category	Percent	Total Construction* Labor Requirements
Male	95	13,158
Female	05	692
Professional	04	559
Management	09	1259
Sales	**	0
Clerical	06	839
Craftsmen	59	8255
Operators	03	420
Transportation Operators	04	559
Laborers	14	1959
Service	**	0

*For the 1978-1985 period, Source: Table 6.
**Less than 1 percent.
Source: U.S. Bureau of the Census, 1970.

Table 8.
Distribution by Income Class of Construction Workers*
(Number of Workers and Percent)

Occupational Class	*Income Classes* $1 to $4,999		$5,000 to $9,999		$10,000 to $14,999		$15,000 +		Total
Professional	(08)	45	(29)	162	(41)	229	(22)	123	559
Management	(11)	138	(28)	353	(31)	390	(30)	378	1259
Sales	(12)	0	(42)	0	(25)	0	(21)	0	0
Clerical	(42)	352	(41)	344	(10)	84	(07)	59	839
Craftsmen	(18)	1486	(47)	3880	(25)	2063	(10)	826	8255
Operators	(22)	92	(51)	214	(25)	105	(02)	9	420
Transportation Operators	(22)	123	(65)	363	(11)	62	(02)	11	559
Laborers	(41)	803	(48)	940	(09)	176	(02)	40	1959
Service	(35)	0	(43)	0	(14)	0	(08)	0	0
Total	(22)	3039	(45)	6256	(22)	3109	(10)	1446	13,850

*These distributions are for the total impacts accruing over the 13 year period of analysis. Numbers in parentheses are in percent.

Although the direct distributional effects are of interest, the distribution of the indirect employment and income effects is the principal focus of this analysis. For this purpose, the Massachusetts input-output model was used to estimate the indirect employment impacts of the power plant construction. These results are shown in Table 9.

The information in Table 9 reveals that the major indirect employment effects accrue to the manufacturing, retail trade and service sectors. Moreover, the total indirect employment is, as expected, much greater than the direct employment shown in Table 6.

Table 10 gives a comparison of the distribution of income by class of the direct effects, the indirect effects, these two effects combined, and the reference income distribution for the state. The results indicate that the indirect effects accrue more to lower income groups than do the direct effects. This occurs because the income in the retail trade and service sectors is distributed toward the lowest income classes. Only three percent of the retail trade service work force consists of workers classified as professional. Moreover, more professional workers in the services sector belong to the lowest income classes than is the case for all professional workers. This may reflect lower wage rates and/or variations in the type of professionals employed in the services sector.

Table 9.
Indirect Employment Impacts of Construction of a 2300 Mw Nuclear Power Plant in Massachusetts (Workers)*

	1978	1979	1980	1985	1990	Total*
Total	1423	2673	5327	1393	576	20,891
Farm	0	0	0	0	0	0
Mining	1	2	3	1	0	22
Construction	5	10	22	3	2	137
Manufacturing	112	204	405	99	39	2,699
Trans. & Pub. Ut.	53	101	206	52	20	1,356
Wholesale Trade	83	156	315	81	33	2,112
Retail Trade	256	480	966	248	101	6,477
Finance, Ins. & R.E.	53	101	206	52	20	1,356
Services	260	493	1002	263	111	6,732
Government	0	0	0	0	0	0

*Total is for 13 years.

The overall impacts of the power plant construction, then, were distributed toward the middle income classes (Classes 2 and 3 of Table 10).[1] The results, therefore, indicate that the distribution of indirect impacts is significantly different from the distribution of direct effects. Consequently, a distributional analysis which focuses upon the direct effects may be quite misleading from a policy or planning perspective.

Indirect and direct labor requirements by occupation or skill class (Table 11) were also calculated from the information in Table 9 and from Census data. In comparison with the distribution of labor requirements by occupational class without the project (which closely approximates that in Column 3 of Table 11), the demands for craftsmen and laborers were projected to increase while the demands for professionals, clerical, operators and service workers were projected to decrease.

LIMITATIONS, IMPLICATIONS AND CONCLUSIONS

Evaluation of investment alternatives has often been carried out in a multiple objective framework. Distributional analyses have, however, usually focused only upon direct effects. Yet, as indicated above, the indirect distributional impacts may be quite different from the direct ones.

Several conclusions flow from this analysis. First, more emphasis is needed on empirical measures of indirect distributional impacts. Without such information the question of which groups and sectors gain from program implementation cannot be fully answered. Second, additional research as to the incidence of program costs, of nonwage and salary income, and of induced effects is required.

The analysis presented is, however, not without limitation. First, the input-output approach assumes fixed coefficients. Of particular importance is that distributional results are affected by the level of

[1]In no time period was the construction of the power facility large enough in relation to the state's economy to significantly change the distribution of income for the state as a whole.

Table 10.
Distribution of Direct and Indirect Impacts by Income Class (in Percent)*

	Class 1 $1 to $4,999	Class 2 $5,000 to $9,999	Class 3 $10,000 to $14,999	Class 4 $15,000 +
Direct	22	45	22	10
Indirect	48	35	12	5
Direct and Indirect	37	40	16	7
Reference Distribution	40	39	14	7

*These distributions are for the *total* impacts accruing over the 13 year period.

Table 11.
Direct and Indirect Labor Requirements by Occupation Class (in Percent)

Occupational Class	*Direct*	*Indirect*	*Total*
Professional	04	17	12
Managers	09	10	10
Sales	*	12	07
Clerical	06	20	14
Craftsmen	59	10	30
Operators	03	09	07
Transportation Operators	04	03	03
Laborers	14	03	08
Service	*	15	09

*Represents less than one percent. Requirements are for the total impacts accruing over the 13 year period of analysis.

employment and by occupational mobility. For example, if full employment and occupational immobility are assumed then the occupational sectors "gaining" in the case study above will be offset by losses in the same sectors elsewhere in the nation. On the other hand, if there is full employment coupled with occupational mobility, then the distributional effect may be confined to the locality in which the investment is situated. Income distribution effects should also be evaluated for both expenditure changes and income changes caused by the program being evaluated. Limitations of time and resources, however, confine this study to the evaluation of the wage and salary income changes.[2] Moreover, Census information is updated only once each decade. Finally, the results are limited by the degree of aggregation inherent in the Census data.

[2]From a conceptual standpoint, expenditure changes could, however, be evaluated within the input-output procedure outlined.

The model postulated can, however, provide more complete information of the distributional impacts of investment program alternatives. A resurrection of the secondary or indirect impact concept as a means for evaluating *distributional* effects is therefore recommended.

REFERENCES

Bonnen, James, 1968, "The Distribution of Benefits from Cotton Price Supports," in Samuel B. Chase, ed., *Problems in Public Expenditure Analysis*, Washington, D.C., The Brookings Institute.

Collins, R. A., 1977, "The Distributive Effects of Public Law 92-500," *Journal of Environment Economics and Management*, Vol. 4, No. 4

Freeman, A. Myrick, 1967, "Six Federal Declaration Projects and the Distribution of Income," *Water Resources Research*, Vol. 3, No. 2.

Haveman, Robert H., 1965, *Water Resource Investment and the Public Interest*, Nashville, Vanderbilt University Press.

Hohen, John, L. W. Robbins and K. R. Ansche, 1980, "Benefits, Costs, and Distributional Consequences of a Publicly Assisted Marketing Co-operative," *Amer. Journal of Agr. Econ.*, Vol. 62, No. 2.

Infanger, Craig and W. R. Butcher, 1974, "Individual Income Redistribution and Public Provided Irrigation: The Columbia Basin Project," *Amer. Journal of Agr. Economics*, Vol. 56, No. 4.

Ngenge, Wawa, 1979, *Direct and Indirect Income Distribution Impacts of Investment Programs*, Amherst, unpublished M.S. Thesis.

Thurow, Lester C., 1980, "The Indirect Incidence of Government Expenditures," *American Economic Review*, Vol. 70, No. 2.

Treyz, George, 1975, *The Massachusetts Economic Policy Analysis Model*, Amherst: The University of Massachusetts.

____________, Benjamin Stevens and David Erlich, 1979, *An Electric Core Model for State Policy Analysis*, Amherst: University of Massachusetts.

U.S. Bureau of the Census, 1970, *1970 Census of the Population*, Washington, D.C.