The Incidence of Local Water Pollution Abatement Expenditures: A Case Study of the Merrimack River Basin

A thesis presented

by

Sharon M. Oster

to

the Department of Economics

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

in the subject of

Economics

Harvard University

Cambridge, Massachusetts

June, 1974

PREFACE

I would like to take this opportunity to thank several people who have helped me in this research. Particular thanks are due my two thesis advisors, Richard Caves and Marc Roberts. Professor Caves suffered good-naturedly through numerous revisions of this manuscript and, through his careful reading, prevented me from making a number of serious errors. Professor Roberts, who first stimulated my interest in the environmental area, provided significant direction in Part I of this thesis and encouragement throughout.

I would also like to thank Howard Hencke, whose technical advice significantly improved the overall quality of Chapters 2 and 5. I would also like to thank Howard for encouraging me when the end of this thesis seemed very far away.

Finally, I would like to thank Jill Stephens, who typed this thesis and bore my endless editorial changes with great good humor.

The empirical work of this thesis was funded by the Environmental Protection Agency.

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

SYNOPSIS

This study is divided into two parts: Part I is an analysis of the determinants of local government expenditures on water pollution abatement facilities; Part II is an investigation of the incidence of costs and benefits of public environmental programs. Thus, I consider issues in the areas of social choice and income distribution within the context of environmental economics. Empirical data from the Merrimack River Basin formed the basis of this work.

In Part I of this thesis, I am concerned with identifying the types of cues which local governments respond to in setting levels of water pollution abatement expenditures: are these cues strictly imposed from the federal level, or do localities in fact have sufficient flexibility to respond to community preferences? In pursuance of an answer to this question, I analyze several alternative models of government decision-making and trace through the implications of these alternative models for the levels of water pollution abatement selected.

Two general models of government decisions were analyzed: the adding machine state and the organismic state. The view that the state may be treated as a simple adding machine has a long history. The metaphor is perhaps best associated Buchanan,[1] Buchanan and Tullock,[2] and Downs.[3] In this

[1] James Buchanan, "The Pure Theory of Government Finance: A Suggested Approach", Journal of Political Economy, Vol. LVII, No. 6 (December, 1949), pp. 496-505.

[2, 3] See page vii .

paradigm, government structure is a function strictly of community characteristics; thus, the analysis concentrates on predicting preferences entirely on the basis of the latter. If we abstract from problems of uncertainty, this model predicts that expenditures on public goods perfectly mirror community preferences. Within the constraints of this model, two sub-models, two rules of aggregating preferences, may be devised. In the traditional theory, typically, a one man/one vote voting paradigm has been assumed. More recently, some attention has been devoted to an interest group voting model; here, homogeneous aggregates of voters are clustered about specific issues. This latter model suggests that intensity of preferences, insofar as this is revealed is membership in an interest group, is counted in the decision process. In the traditional one man/one vote model, intensity of preferences is largely ignored.

As an alternative to the adding machine state, some researchers have posited an organismic state. According to this model, politicians themselves have preferences which are not simply derivative from voters' preferences. Instead, government decisions depend upon some sum of voters' preferences,

---

[2]Buchanan and Tullock, The Calculus of Consent (Ann Arbor, University of Michigan Press, 1962).

[3]Anthony Downs, An Economic Theory of Democracy (New York, Harpers, 1957).

coupled with the independent preferences of the political actor. Here, state performance can be predicted only by considering the structure of local government in addition to community preferences.

Estimates of the relative importance of community preferences versus technical constraints in determining local sewage treatment plant expenditures were made under the four alternative specifications of government decision-making. In addition to estimating the importance of local preferences in the environmental area, I considered two side issues:

(1) Are politicians sensitive to interest groups and, in particular, to property owners in setting water pollution abatement expenditures?

(2) Do the independent preferences of decision-makers mitigate the influence which local preferences exercise in determining expenditure levels?

The empirical work in this thesis suggested that slightly more than 35 percent of intermunicipality variance in water pollution abatement expenditures can be explained by community preferences. Town income levels, proximity to the river, and the distribution of property ownership were particularly significant. Thus, despite relatively stringent federal regulations and standards, individual towns retain significant flexibility in determining their sewage treatment plant expenditures. The empirical work in this thesis provided only minimal support for the interest group model of government.

On the other hand, there was some evidence that levels of political competition affect the extent to which community preferences are reflected in the decision process. In particular, the evidence suggests that low levels of political competition, if measured as plurality in elections, result in high levels of water pollution abatement expenditures. Somewhat less reliable evidence suggests, furthermore, that low levels of political competition encourage towns to finance these expenditures through increases in property taxation, rather than through selective reductions in other expenditure categories.

Part II of this thesis is an empirical investigation of the incidence of the costs and benefits of water pollution abatement; the Merrimack River Basin is used as a case study.

Previous studies in the field of environmental economics have assumed that such expenditures are financed exclusively through property tax increases; in this study, I attempt to determine the source of pollution abatement funds more carefully. In particular, local governments have two basis methods of raising funds for new expenditures: they can increase the property tax, or they can reduce other expenditures. In determining the new revenue source, I compare the with-pollution expenditure town budget with a hypothetical budget constructed assuming no pollution abatement occurred. In this study, this hypothetical budget is constructed by extrapolating historical tax and expenditure levels of study towns according to certain assumed budget growth rates. Further analysis identified areas in which expenditure substitution is likely to occur.

The cost analysis suggested that almost half of the new expenditures for water pollution abatement were financed through expenditure substitution. Expenditures in the areas of public safety and parks and recreation were particularly susceptible to cut-backs.

On the basis of this analysis, the cost incidence of water pollution abatement was evaluated. The evidence suggests, first, that costs are regressive: that is, income increases faster than costs; and second, that these incidence estimates are very sensitive to the choice between property taxation and expenditure substitution.

In order to determine the incidence of benefits of water pollution abatement, a telephone survey was conducted. Two hundred people living in the Merrimack River Basin were interviewed for recreational use patterns and willingness to pay for river quality improvements. An analysis of the data indicated that the benefits of river quality improvements increase more than proportionately with income, accrue more to homeowners than to renters, and increase with the educational level of the respondent.

Taken in full, the empirical evidence of this thesis suggests, first, that the net benefits of river quality improvements increase as income increases; and, second, that these maldistributional effects may be significantly modified by changes in local government financing mechanisms.

1. Introduction

In the field of environmental economics, it is possible to distinguish four major problem areas which have received attention. First, substantial research has been done using environmental degradation as an example of the more general problem posed by externalities for the achievement of Pareto optimality by competitive market mechanisms. Perhaps the greatest efforts in the environmental area have been concentrated on a second problem: quantifying the net benefits of public environmental programs. Research interest in the government has been particularly devoted to this strict efficiency measurement.

This study concentrates on two environmental problems which have received somewhat less attention. First, how are decisions about optimal levels of environmental quality made? Since the environment is appropriately viewed as a public good, the output decision clearly introduces issues in the areas of social choice and the nature of political decision processes. This study further considers the <u>incidence</u> of costs and benefits of public environmental programs; current public concern with distributional issues suggests traditional aggregative cost-benefit analysis is insufficient. Thus, this study is primarily an empirical investigation of problems of social choice and equity posed by environmental quality decisions.

1.1 The Problem

An externality exists whenever the production decisions of one economic agent enter directly into the production function of another.[1] Under these conditions, the Pareto optimality of a competitive equilibrium is no longer guaranteed;[2] it is in this sense that externalities become a problem both for economists and for policy makers.

Water pollution is a prime example of an externality: firms and municipalities in the process of producing some good or service also generate a secondary product--water pollution. This pollution in turn affects other firms, municipalities, and, finally, consumers. Given the existence of transactions costs, uncertainty, and inequalities in bargaining power, all of which prevent the market mechanism from fully internalizing the social costs of water pollution, the government has increasingly begun to intervene and attempt to directly alter the national level of water pollution.

---

[1] A great deal of literature exists on defining externalities, including Paul Samuelson, Foundations of Economic Analysis (Cambridge, Harvard University Press, 1947), pp. 208-256; James Buchanan and William Craig Stubblebine, "Externality", Economica, Vol. XXIX, No. 116 (November, 1962), pp. 371-384; E. J. Mishan, "Reflections on Recent Developments on the Concept of External Effects", Canadian Journal, Vol. XXXI, No. 1 (February, 1965), pp. 1-34.

[2] Kenneth Arrow, "Political and Economic Evaluation of Social Effects and Externalities", in Margolis, The Analysis of Public Output (New York, National Bureau of Economic Research, 1970), pp. 1-23.

The usual stated objective of public projects in general and of water pollution projects in particular is to increase social welfare, where social welfare is defined as some function of the utilities of individuals in that society.[3] In practice, the type and extent of government action is decided primarily on the basis of efficiency[4]: programs are adopted on the basis of comparisons between the present value of benefits and costs of the project. In many cases, however, application of strict cost-benefit analysis is in conflict with the purported social welfare goal.

In particular, from a social welfare perspective, there are really two problems with an exclusive reliance on cost-benefit based project evaluation. In the first place, in many instances, the analysis considers only the aggregate costs and benefits of pollution control. A mapping is then made, at least implicitly, between the net income generated and the overall utility of the project. The issue of who benefits and who pays is not considered. On the other hand, both aggregate levels of income and the distribution of income enter into the usual formulation of the social welfare

---

[3]Kenneth Arrow, Social Choice and Individual Values (New Haven, Yale University Press, 1951).

[4]J. T. Bonnen, "The Absence of Knowledge of Distributional Impacts: An Obstacle to Effective Policy Analysis and Decisions", in Haveman & Margolis, Public Expenditures and Policy Analysis (Chicago, Markham Publishing, 1970), pp. 246-270.

function.[5] Imagine, for example, that there are two groups in a society, one of which pays $10 for pollution control and receives no benefits, and the other which pays nothing for abatement and receives $20 in benefits. Naive cost-benefit analysis, considering only $10 versus $20 would recommend adoption of the program. This program, however, would (1) not be Pareto-approved, and (2) <u>might</u> not be approved from a social welfare perspective.

There is, however, a more subtle problem with the application of cost-benefit analysis. Suppose the costs and benefits for the two groups were calculated separately, and we found that for both groups the benefits of the program in question exceeded its costs. Adoption of the program, then, in contrast to the example given above, would be Pareto-approved. However, if the community has a commitment to an equal distribution of real income, and the proposed project differentially benefits the richer of the two groups, it still might be an inferior move from the perspective of maximizing social welfare.

In short, if water pollution abatement programs are to be consistent with the policy goal of increasing social welfare, distributional as well as aggregative effects of program levels must be considered.

---

[5] Robert Haveman, <u>Water Resource Investment and the Public Interest</u> (Tennessee, 1965), Chapter 6.

This study attempts to determine the extent to which, in the context of the discussion above, current water pollution abatement programs in fact act to increase net social welfare. The study itself is divided into two parts.

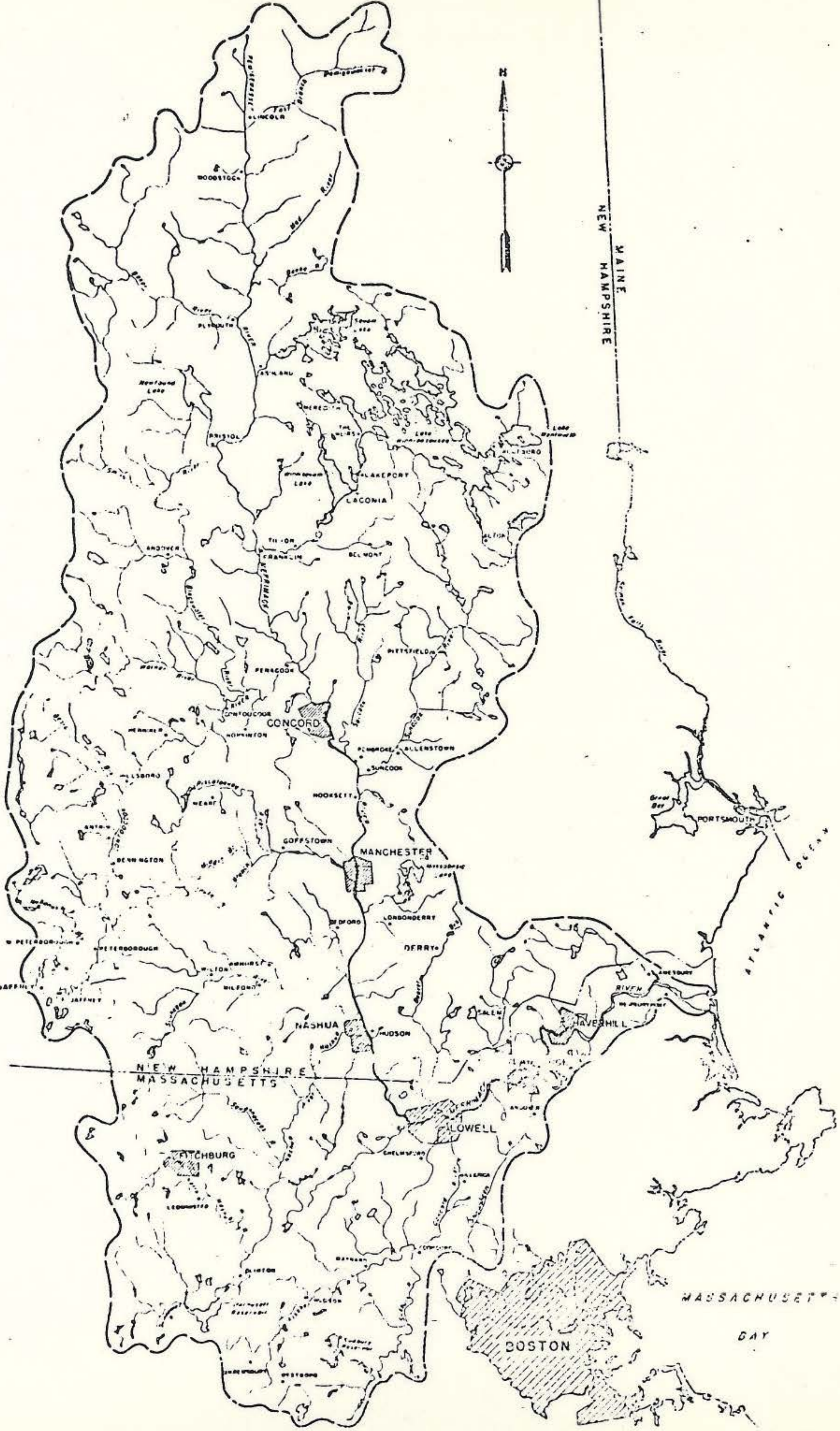
In Part 1, Chapters 2 and 3, I consider the determinants of local government expenditures on water pollution abatement facilities. In particular, I am concerned with identifying the types of cues which local governments respond to in setting levels of water pollution abatement expenditures: are these cues strictly imposed from above--viz. from the federal level--or do local governments in fact respond to local preferences? In pursuance of some answer to this question, I analyze several alternative models of local decision making, and trace through the implications of these alternative models for water pollution abatement expenditures. Some econometric evidence on the relative viability of each of the models is presented. The treatment of alternative models of government is very much in the tradition of conventional Industrial Organization, in the sense that local governments are assumed to be resource-allocating organizations with specified objective functions and constraints; the attempt is made to use these objective functions and constraints to predict expected output of public goods and services.

In Part 2 of this study, the effects of these local government expenditures on the distribution of income in the study area is considered. In particular, I consider the distribution of the costs of government expenditures on water pollution abatement among income groups relative to the distribution of benefits. The empirical work which underlies this analysis was conducted in the Merrimack River Basin; a description of the study area follows in Section 1.2.

1.2 Description of the Study Area

The Merrimack River Basis has its headwaters in the White Mountains in New Hampshire. The major stem is formed by the confluence of the Pennigewasset and Winnepesaukee Rivers at Franklin, New Hampshire. From Franklin, the River runs south for 78 miles to the Massachusetts border, where it turns abruptly east for about 45 miles, emptying into the Atlantic Ocean at Newburyport, Massachusetts. One of the main branches of the river system is the Nashua River, which originates in Central Massachusetts, flows into New Hampshire, and tributary to the Merrimack at Nashua, New Hampshire. A map of the Basin follows in Figure 1.1.

The quality of the water in the main stem Merrimack is among the worst in the country. In 1972, the river was classified as the third most polluted waterway in the nation, trailing only the Cayahoga in Ohio, and the Houston Ship Canal in Texas. The Merrimack is inundated with both



MERRIMACK RIVER
BASIN MAP

industrial and municipal untreated wastewaters. The major industries in the basin are heavy BOD polluters and include leather tanning, paper, textiles, and meat packing. Exotic water quality contaminents enter the River from the tanneries, plastic industries, and metal plating works. The wastes from much of the industry in the basin are currently not receiving any treatment.

Municipal wastes are responsible for a large portion of the poor water quality in the basin. The sewered population of the basin approached 700,000 in 1970. (A list of the towns and cities in the study area is provided in Table 1.1; median income levels are provided to illustrate the heterogeneity of the area towns.) In 1964, treatment reduced the bacteria, suspended solids, and BOD loading by less than 20 percent. Over 90 percent of the municipal wastes enter the water untreated, and the major urban centers in the area have only recently begun to improve wastewater treatment. The lack of treatment facilities is compounded by the prevalence of combined sewers in the basin.

Recent surveys confirm the low water quality of the basin. The full classification of the basin, recently done by the Army Corps, is given in Table 1.2. Many reaches of the river maintain no dissolved oxygen; no fish can live in the water, and the resultant anaerobic decomposition of organic materials produces noxious odors. Fecal coliform counts

TABLE 1.1

Median Income of Towns in the Merrimack

TOWN	INCOME	TOWN	INCOME
Alton	$ 7233	Laconia	$ 7696
Andover	12730	Lancaster	7967
Bedford	11677	Lawrence	7367
Belmont	7000	Leominster	8985
Billerica	10928	Lowell	7376
Boscawen	6569	Lunenberg	10316
Bow	7500	Manchester	7500
Chelmsford	13092	Meredith	8022
Claremont	8778	Merrimack	11384
Concord	7589	Methuen	9739
Dracut	10282	Milford	9947
Fitchburg	7676	Nashua	9302
Franklin	7523	New London	12000
Gilford	10720	North Andover	10249
Goffstown	6626	Northfield	6800
Gorham	8512	Pembroke	8923
Groveland	11052	Peterborough	10719
Haverhill	7631	Pittsfield	8707
Henniker	7500	Plymouth	4470
Hillsboro	7242	Sanbornton	8000
Hinsdale	9317	Tewksbury	11250
Hooksett	8683	Tilton	6843
Hopkinton	10802	Warner	7000
Hudson	10596	Westminster	10250
Jaffrey	9670	Wolfeboro	8791

TABLE 1.2

Present Condition of the Merrimack River Basin Area

RIVER MILE From-To	RIVER BEACH From	To	PRESENT CONDITION
0-11.80	Atlantic Ocean	Rocks Village Bridge Haverhill, Mass.	D & C
11.80-21.85	Rocks Village Bridge Haverhill, Mass.	Creek Brook Haverhill, Mass.	D & U
21.85-28.99	Creek Brook Haverhill, Mass.	Essex County Dam Lawrence, Mass.	D & U
28.99-33.03	Essex Co. Dam Lawrence, Mass.	Fish Brook Andover, Mass.	D & U
33.03-40.60	Fish Brook Andover, Mass.	Pawtucket Dam Lowell, Mass.	D & U
40.60-47.35	Pawtucket Dam Lowell, Mass	Tyngsborough Bridge Tyngsborough, Mass.	D & U
47.35-49.82	Tyngsborough Bridge Tyngsborough, Mass.	New Hampshire/Mass. State Line	D & U
49.82-54.80	New Hampshire/Mass. State Line	Merrimack River (Above conf. of Nashua River)	C
54.80-68.05	Merrimack River (Above conf. of Nashua River)	Goffs Falls Manchester, N. H.	C
68.05-73.14	Goffs Falls Manchester, N. H.	Amoskeag Dam Manchester, N. H.	C
73.14	Amoskeag Dam Manchester, N. H.	Eastman Falls Dam Franklin, N. H. (At conf. with Winnipesaukee River)	C

Classification Key

A: Potentially acceptable for public water supply after disinfection.

B: Suitable for bathing, other recreational uses, agricultural uses; industrial processes and cooling; excellent fish and wildlife habitat; good aesthetic value; suitable for public water supply with appropriate treatment.

C: Suitable for fish and wildlife habitat; recreational boating and industrial processes and cooling.

D & U: Suitable for power, navigation, and transportation of sewage and waste and certain industrial uses.

of ten times the standard for body contact recreation have been recorded. Paper fibers line the river banks, and in some places are as thick as cardboard. Pesticides are present in concentrations of over three times the standard for treated wastewater. In short, the Merrimack River Basin provides a real challenge to the efficacy of government programs in achieving high levels of ambient water quality.

PART I:

An Analysis of Public Decision-Making in the Area of Water Pollution Abatement

2. The Determinants of the Water Pollution Abatement Expenditures of Local Governments

There is a significant amount of variance in intermunicipality expenditures on water pollution abatement. Is this variance a function of technical variables, as, for example, population and quantity of waste discharged; or is it a reflection of cross-municipality differences in community preferences for clean water? Clearly, the answer to this question will affect the way in which the end results of new water pollution abatement legislation are viewed. In particular, the enthusiasm or disapprobation with which the distributional effects of these new programs are viewed depends to some extent on whether those distributional effects constitute a secondary result of the achievement of other community preferences or whether they result from the imposition of federal legislation. Perhaps more importantly, to the extent that the distributional effects of new water pollution abatement programs[1] are viewed as adverse, determining the causes of differences in expenditure levels will help to identify the most appropriate mechanism by which that pollution abatement level and, hence, distributional effects may be changed.

---

[1]Distributional effects are analyzed in Part 2 of this study.

In this chapter, I attempt to get a grip on the causes of variance in local water pollution expenditure levels by examining a number of alternative models of the way in which local governments formulate expenditure decisions. In particular, I focus on the extent to which alternative models predict that community preferences will be translated into particular water pollution abatement levels. In Chapter 3, some econometric evidence predicated on each of the alternative decision models developed here is presented; the relative viability of each of the models in terms of predicting expenditure levels in this area is thus illustrated, and, finally, the relative importance of each of the technical and community preference variables for the final expenditure level is estimated.

2.1 The Models

Any model of the political decision process must begin by characterizing two basic dimensions of the political organization under analysis: the motivations of the actors within that organization and the opportunity set which constrains those actors. In this sense, the analysis of the state parallels much of the work done on the theory of the firm. In particular, the state may be viewed as a rational resource-allocating organization responsible for some specified set of pricing and output decisions.

Much of the analysis done on the theory of the firm concentrates on identifying and clarifying the relationship between industry structure and industry performance. There is a similar attempt in this study to use variables reflecting government structure to predict state output and pricing decisions. Two sets of structural characteristics will be considered: government organizational and institutional variables, and community characteristics.

Past work on political organizations has relied upon one of two metaphors as a description of the state: the adding machine state versus the organismic state. A set of motivations and opportunities are implicit in each of these two models. In this chapter, these two basic metaphors of the state will be reviewed and extended; the motivations and opportunity set implicit in each of the models will be defined;

and, finally, the predictions yielded by each of the models on the important determinants of intermunicipality variance in the level and financing of water pollution abatement programs will be considered.

The view that the state may be treated as a simple adding machine has a long history. The metaphor is perhaps best associated with the work of Buchanan[2], Buchanan and Tullock[3], and Downs[4]. In this paradigm, government structural attributes are a function strictly of community characteristics; thus, the analysis concentrates on predicting performance entirely on the basis of the latter.

In Buchanan's model, the state is individualistic; it acts strictly as "a set of processes or machine which allows collective action to take place".[5] Buchanan's model of the state is limited even further: he suggests that the need for collective action, and, by extension, the need for the state, arises only in the case of "public" or indivisible goods. Thus, Buchanan's state is limited both in terms of

---

[2]James Buchanan, "The Pure Theory of Government Finance: A Suggested Approach", Journal of Political Economy, Vol. LVII, No. 6 (December, 1949), pp. 496-505.

[3]Buchanan and Tullock, The Calculus of Consent (Ann Arbor, University of Michigan Press, 1962).

[4]Anthony Downs, An Economic Theory of Democracy (New York, Harpers, 1957).

[5]Buchanan and Tullock, op. cit., p. 13.

its motivations, and in terms of its sphere. The benefits from the production of one unit of a private good accrue strictly to the purchaser of that good; in this sense, we say that private goods are divisible, or that their benefits are appropriable. The same is not true of a public good. The production of defense, for example, affects everyone, whether people choose to "purchase" defense or not. Since benefits accrue without individual purchase of the good, there is no way for the free market pricing system to register preferences. It is here that Buchanan's state intervenes, and acts to sum up all the utilities available for the production of the indivisible good and, thus, determine the optimal output of that good.

Downs humanizes Buchanan's theory of the state somewhat by attributing motivations to state actors (politicians). Downs' politicians choose output and pricing bundles in order to maximize their vote-getting ability. Moreover, the sphere of the state is not limited to the area of pure public goods. The attribution of motivations and utility functions to politicians, coupled with the extension of the arena of government, broadens the Buchanan state considerably. However, inasmuch as Downs' votes are simple summations of voter utility functions, in the final analysis his state too operates to maximize voter utility. Once again, performance in terms of output and pricing of public goods is determined, albeit more indirectly, by community attributes.

The adding machine model is implicit as well in much of the more basic theoretical work done on social welfare functions: Arrow[6], Bergson[7], Samuelson[8], and others all assume that government acts to maximize some function (here W) which has as its arguments only the utilities of the citizens in that community. The primary debate in this literature concerns not the nature of the arguments of W, but only the form of W; that is, the tallying method which is to be used by the state machine.

It is interesting to consider the implications of the adding machine model in terms of the motivations of local politicians. The only input into the machine is the preferences of voters. If we assume that there exists some one-to-one correspondence between citizen preference on an issue and citizen vote for a political office holder, then the adding machine model implies that politicians are motivated strictly by votes. Indeed, in the Downs model, this objective function is made explicit.

---

[6] Kenneth Arrow, Social Choice and Individual Values (New Haven, Yale University Press, 1970).

[7] Abram Bergson, "A Reformulation of Certain Aspects of Welfare Economics", Quarterly Journal of Economics, Vol. LII, No. 2 (February, 1938), pp. 314-344.

[8] Paul Samuelson, "The Pure Theory of Public Expenditures", Review of Economics and Statistics, Vol. XXXVI, No. 4 (November, 1954), pp. 387-389.

Within the context of the adding machine metaphor, the political science literature suggests two functional forms for the social welfare function; two possible tallying methods for the machine.

In the first model, best associated with Duncan Black[9], and later with Davis and Hinich[10], the politician maximizes a social welfare function which has as its argument a binary variable, yes versus no votes.

We can consider the Black, Davis, Hinich model in somewhat more precise terms. Suppose we have a public sector which consists of three goods, say x, y, and z. Assume further that voters have some well-defined utility function over these three goods. Then:

$$U_i = f\ (x,y,z) \qquad i = 1 \ldots n,\ \text{voters}$$

Let

$$V_i = \begin{cases} +1 & \text{if } \dfrac{\partial U_i}{\partial x} > 0 \\ -1 & \text{if } \dfrac{\partial U_i}{\partial x} < 0 \end{cases}$$

Then, the Black, Davis, Hinich politician maximizes

2.1 $$W = \sum_{i=1}^{n} V_i$$

---

[9] Duncan Black, The Theory of Committees (Cambridge, Cambridge University Press, 1968).

[10] Otto Davis and Melvin Hinich, "A Mathematical Model of Policy Formation in a Democratic Society", in Joseph Bernd, Mathematical Applications in Political Science, Vol. 2 (Dallas, Arnold Foundation Press, 1966), pp. 14-38.

The point at which this function is maximized depends of course on the functional form specified for the utility functions. However, it is clear that the result of maximizing the welfare function specified in 2.1 will not, in general, be equivalent to the economist's usual welfare maximum; unlike the conventional maximization form, equation 2.1 takes no account of relative intensity of preferences.

The interest group model provides an alternative specification for the welfare function to be maximized, still within the context of the adding machine metaphor. In this formulation, the politician considers homogeneous aggregates of voters clustered about specific issues, rather than individual voters each with multiple preferences. It should be noted, however, that in this model too the politician makes his decisions strictly on the basis of voter preference.

Perhaps the best application of the interest group model to the political decision process has been the work of Dorfman and Jacoby[11]. Dorfman and Jacoby construct an artificial river valley, Bow River Valley, and equip it with water pollution and a regional commission designed to alleviate the problem. They then attempt to develop a mathematical

---

[11] Robert Dorfman and Henry Jacoby, "A Model of Public Decisions Illustrated by a Water Pollution Policy Problem", HIER Discussion Paper #91 (Cambridge, Mass., October, 1969).

model to predict the level of expenditure required by the commission of the each of the polluters in the Bow Valley. In constructing this model, Dorfman and Jacoby use a type of interest group model in which the three interest groups represented are two polluting towns and a canning industry. The commission members then make a decision by weighing each of these separate vote aggregates.

The primary characteristic of interest group models is that, in some imperfect fashion, interest groups introduce intensity of preferences into the welfare function maximized by the politician. The linkage between preference intensity and activity in an interest group is clearly imperfect; the lobbying and general activity associated with the power of a group clearly depend, not only on preference strength, but on the opportunities available to the individual to manifest these preferences. In short, the potential lobbyist requires time and information, and often money, as well as demand. Keeping in mind this caveat, we can approximate the interest group model as a maximization by local politicians of a function of the form:

2.2 $$W = \sum_{i} w\, U_i$$

where w is the weight attached by the politician to each group and reflects the ability of that group to make its preferences manifest.

In both the individual and the interest group models described above, the primary goal of the political actor may be viewed as political popularity. The decision by the politician to maximize equation 2.1 versus 2.2 depends only on his view of the way in which the political process operates; that is, on whether he considers it more politically viable to make a few people very happy, or to make a larger number of people somewhat less happy.

There is, however, a second model of the state which has received somewhat less attention in the economics literature. In this model, termed the organismic state, politicians themselves have preferences which are not simply derivative from voters' preferences. Governmental decisions then depend upon some sum of voters' preferences coupled with the independent preferences of the political actor. According to this paradigm, state performance can be predicted only by considering the structure of local government in addition to community characteristics.

In analyzing the organismic model of the political decision process, it is useful to draw on the Industrial Organization literature on the managerial theories of the firm. In particular, the nonprofit maximizing theories of Williamson[12],

---

[12] Oliver Williamson, "Managerial Discretion and Business Behavior", American Economics Review, Vol. LIII, No. 5 (December, 1963), pp. 1032-1057.

Baumol[13], and Marris[14] are quite relevant.

The dominant characteristic shared by all of these models is that they predict that, under certain conditions, the firm may act in response to motivations other than profits. The more prominent motivations suggested are revenue (Baumol), growth (Marris), and managerial perquisites (Williamson). To the extent that any one or another of these alternative goals of the firm are operative, the final equilibrium price and output position of the firm will diverge from the usual competitive equilibrium.

Firms can respond to one or another of these alternative goals only insofar as the market in which they operate is less than perfectly competitive; where no market power exists, only a strict adherence to profit maximization goals will permit the firm to remain afloat. This points out the necessity of identifying the opportunity set of the actor as well as his motivations; in a fiercely competitive market, the motivations of the manager are largely irrelevant: he is constrained to maximize profits. Formally, the opportunity set of the firms' managers is represented as a profit level constraint on the utility function of the manager.

---

[13]William Baumol, Business Behavior, Value and Growth (New York, Harcourt, 1959), pp. 45-50.

[14]Robin Marris, "A Model of the Managerial Enterprise", Quarterly Journal of Economics, Vol. LXXVII, No. 2 (May, 1963), pp. 185-209.

Marris further specifies the critical constraining profit level as that level which allows the firm to just avoid take-over. For other economists, the critical profit constraint is somewhat less closely defined; but, in general, it involves some notion of a profit level high enough to insure job security for the decision maker.

Consider now the extent to which these alternative theories of the firm may be applicable to a model of the decision process of government. There is a clear analogy between votes and profits; in fact, the adding machine model of the state is a relatively straightforward application of the competitive model of the firm. In the model of the organismic state, we posit instead a politician who formulates tax and expenditure policy in an attempt to maximize some function $\hat{U}$ subject to a voting constraint. In place of 2.1 or 2.2, we have the following characterization of the political process:

2.3 $$\max. \ \hat{U} = \hat{U}\ (a, b, c)$$

subject to

either a. $\sum_i V_i \geq Z$

or B. $\sum_i U_i \geq Z$

Z in this formulation represents some acceptable level of political popularity--if we want to adopt Marris completely, we might characterize Z as the level at which the political actor just insures his reelection. The choice of constraint for (a) or (b) depends on whether we consider the operative political process to comprise interest groups (b), or individual votes (a).

Before we inquire into the nature of the a, b, and c motivating variables, it is useful to consider the conditions under which a non-vote maximizing model might be viable. Here the analogies with the theory of the firm are particularly useful. The ability of a manager to respond to other than profit motivations depends critically on the lack of perfect competition in the economic market place; the ability of a politician to act in a non-vote maximizing manner similarly depends on the absence of perfect competition in the political market place. In some sense, this model substantiates the oft-made political observation that two-party politics improves the representation afforded a community's citizenry.

We can consider now the most likely motivations for the political decision maker, as well as the form of the constraint function he is likely to face. We are concerned here with the motivations and constraints of the elected politician; while the career bureaucrat has many of the same incentives as the elected official, he has a somewhat different constraint function. Since the elected official is the more powerful of the two decision makers in government, we concentrate on him.

In general, we would expect politicians (much like other people) to behave in ways to maximize their own power, salary, perquisites, reputation, and so on. In fact, each of these maximands is closely associated with the size of the government budget controlled by the politician.[15] The analogies between this model of government decision making and Williamson's firm manager are clear. Williamson's manager tries to maximize firm output or revenue in order to enhance his own power, salary, perquisites; in the organismic state model described here, the politician tries to maximize the growth of the public sector, or public output, in order to enhance his position in terms of the same attributes. Williamson's manager is constrained by economic competition; our politician is constrained by political competition.

Consider now the nature of the constraint faced by the politician. The ability of a politician to maximize growth of the public sector is constrained by community preferences as reflected by community votes. Thus, the structural characteristics of the community which act as proxies for those preferences here act as the constraint function. I hypothesize that all else equal--viz all structural attributes of the community held constant--communities in which there is a great deal of political competition will have lower expenditures

---

[15] William Niskanen, Bureaucracy and Representative Government (New York, Atherton, 1971).

on public projects than those communities with very little political competition.

I do not suggest here that political competition is completely irrelevant in the adding machine model of the state. In particular, low levels of political competition in an area may reflect the homogeneity of the population. To the extent that this is true, in a cross-sectional study of municipal expenditures, we would expect low levels of competition to be associated with high variance in the levels of expenditures made. However, it is only in the organismic paradigm that we would predict the mean level of expenditures to be inversely related to the level of political competition.

In short, the organismic state model suggests that the structure of the state, and, in particular, the political competition in a community, may have some independent influence on the performance of that state.

There are thus four plausible models of local government decision making: the adding machine-interest group model, the adding machine-pure democracy model, the organismic-adding machine model, and the organismic-pure democracy model. In the next section of this paper, I investigate the operational differences among these four model specifications in the determination of the level and financing of water pollution control. In Chapter 3, the results of the application of each of the four models to the pollution expenditures in the Merrimack River Basin are presented.

2.2 Implications of the Models of Government Decisions

We can return now to the original question: What are the determinants of the level and financing of local government expenditures on water pollution abatement?

A great deal of empirical work has been done in public finance on identifying the determinants of interstate variance in the level of per capita government expenditures. In most of this work, there is no explicit characterization of the underlying decision process assumed; the independent variables identified are, in fact, appropriate to both the adding machine and the organismic state models, to either interest group or pure democracy voting paradigms.

The earliest econometric work done in isolating the determinants of government expenditures was done by Fabricant in the early 1950's.[16] Fabricant, using 1942 data, explained 72 percent of the interstate variation in per capita government expenditures by the use of three variables: population density, urbanization, and per capita median income. Per capita income has a positive effect on the level of public expenditures: as income increases, both the demand for public services and the supply of potential tax funds also increase. Urbanization is similarly positive, albeit small:

---

[16] Solomon Fabricant, The Trend in Government Activity in the U. S. since 1900 (New York, National Bureau of Economic Research, 1952), especially Chapter 6, pp. 113-139.

the price of supplying public goods as well as the taste for public versus private goods is somewhat higher in urban than in more rural areas. Finally, Fabricant finds a negative coefficient for population density, reflecting economies to scale in the production of public goods.

It should be clear that all three of Fabricant's variables influence government expenditures by altering the utility function of the voter. Population density, by altering the public good/private good price differential, alters the slope of the budget constraint; urbanization similarly alters the slope of the budget line, but simultaneously changes the marginal rate of substitution; finally, income changes shift the budget line parallelly while also affecting the marginal rate of substitution. This voter utility function is relevant to both the adding machine state model, where it represents the only decision input, and to the organismic state model, where it acts as a constraint on politicians' decisions. Thus, the three Fabricant variables can be seen as a subset of the determining variables in either of our models; all three represent proxies for community structure.

A number of economists subsequently attempted to improve Fabricant's R^2 by introducing variables for education[17],

[17] Glenn W. Fisher, "Interstate Variation in State and Local Government Expenditures", National Tax Journal, Vol. XVII, No. 1 (March, 1964), pp. 57-74.

previous expenditures[18], representative tax system yield or tax base[19], population growth[20], and per capita federal expenditures in the area[21]. Further improvements were made by changing the form of the equation from linear to log form.[22]

The first four new variables introduced in these extensions of Fabricant are reasonable; education is a pure taste changing indicator; previous expenditures also indicate something about tastes in an area while simultaneously identifying the existing burden; tax base and population growth both represent proxies for the supply of new tax funds. Kurnow's use of per capita federal expenditures as an independent variable, however, is specious. Kurnow uses as his dependent variable local + state + federal per capita expenditures; the use then of per capita federal expenditures, part of the

---

[18] Ira Sharkansky, "Some More Thoughts about the Determinants of Government Expenditures", National Tax Journal, Vol. XX, No. 2 (June, 1967), pp. 171-179.

[19] Fisher, op. cit.

[20] Richard Spangler, "Effect of Population Growth upon State and Local Government Expenditures", National Tax Journal, Vol. XVI, No. 2 (June, 1963), pp. 193-196.

[21] Seymour Sacks and Robert Harris, "The Determinants of State and Local Government Expenditures and Intergovernmental Flows of Funds", National Tax Journal, Vol. XVII, No. 1 (March, 1964), pp. 75-85; and Ernest Kurnow, "Determinants of State and Local Expenditures Reexamined", National Tax Journal, Vol. XVI, No. 3 (September, 1963), pp. 252-255.

[22] Kurnow, op. cit.

dependent variable, as an independent variable is circular. It increases the R^2 without in any way increasing the true predictive value of the equation.

The Fabricant work and its extensions use either expenditure on all public goods, or some large subclass of public expenditures--viz highways, health, sanitation--as the dependent variable in their equations. The aggregate quality of the dependent variable used allowed certain simplifying assumptions to be made in the analyses; the specificity of the expenditure variable used in this study--viz sewage treatment facilities--suggests that some of these assumptions must be more carefully considered.

It is important first to consider the policy options open to local decision makers. The work on aggregate expenditures assumes that local governments have reasonable flexibility in expenditure policy, and can respond to interregional differences in economic and demographic variables by adjusting this expenditure. In an analysis of local decisions on sewage treatment plant construction, however, the real opportunity set of the decision maker is less clear-cut. It may well be true that federal and state legislation, coupled with technical considerations (viz waste level and flow), completely determine the <u>level</u> of expenditures required for water pollution control; demographic and economic variables reflecting either community preferences or governmental structure will be irrelevant in this situation. These technical and legal constraints on local government activity will be particularly important for the econometric work done in this study. In fact, as I mentioned earlier, identifying the magnitude of the influence of preferences versus technical constraints is an integral part of this study.

The specificity of the dependent variable used in this study introduces a second problem not encountered in the general expenditure work. Previous econometric work has concentrated on the inter-area variance in the level of expenditures; one of the underlying assumptions used in identifying relevant preference variables has been that higher expenditure levels induce higher tax levels. Of course, if the dependent variable in the regression is total town expenditures, then, in the absence of deficit financing, the one-to-one expenditure tax linkage is necessarily correct. In an analysis of a specific expenditure category, however, this linkage can no longer be assumed. Local governments can generate the requisite pollution expenditure by reducing other expenditures as well as by raising taxes. Thus, in this study, some additional care must be exercised in specifying community preference variables. Moreover, while our primary emphasis will be on determining the causes of intermunicipality variance in the level of expenditures on water pollution abatement, we will also consider the determinants of differences in financing schemes used by these towns. This latter tax increase/ expenditure substitution issue is particularly important for the analysis of distributional impact; it will be considered more thoroughly in Chapter 4.

The expected determinants of the level and financing of local government expenditures depend to some extent on which model of the decision process we believe most closely approximates the real world. Nevertheless, there is a substantial subset of variables which can be expected to enter into regressions predicated on all of the models: namely, the community structure variables. This common set of variables will be identified first; we will then consider those variables unique to each of the alternative theories of the state.

Four separate sets of explanatory variables seem to account for intermunicipality variance in the level of per capita local government expenditures on water pollution abatement: demand variables, supply of funds variables, technical constraints, and a set of proxies for public sector distribution. While these four broad categories of variables seem to be relevant to any decision model, the form in which some of these terms enter the regression are model specific.

In this study, median per capita family income, population density, and proximity to the river are used to reflect intermunicipality variance in the demand for sewage treatment facilities. All three of these variables can be expected to affect citizens' utility functions and, therefore, their votes. The first two are standard Fabricant-type terms; the justification for their inclusion in the regression is given ablve. Proximity of an area to the river affects the potential recreational and aesthetic benefits to be culled from any clean-up; a riverside town should, therefore, ceteris paribus spend more on pollution abatement.

Although the model developed here posits some discretion by local decision makers on the level of government expenditures on sewage treatment facilities, technical parameters are nevertheless important. Two towns with equal commitments to clean water may well have different expenditure levels as a result of differences in the initial pollution problem. In short, we require a proxy for inter-area cost of clean-up differentials. Average per capita waste flow (both household and industrial) is used in this work.

The supply of funds available, or the fiscal strength of a town, represents an additional expected input into the level-of-expenditure decision. Two proxies seem to be suitable for use here: the percentage of sewage treatment costs that towns anticipate that the federal and state governments will contribute, and the current year's effective tax rate divided by median family income of the town.

This latter variable unfortunately captures two opposing effects: clearly the current tax rate reflects a town's ability to pay for new projects; on the other hand, a high current tax rate may also reflect the relatively high willingness to pay for public projects of the town. Given the presence in the equation of other strong demand, or willingness to pay, variables, the extent to which the tax rate term will pick up this latter effect will be minimized.

Finally, the baseline distribution of public services and taxes is an important determinant of the level of new expenditures chosen by the government for water pollution abatement. The differences between interest group and purely democratic voting models are captured in the treatment of this subset of terms.

In both the private sector and the public sector, people choose goods on the basis of a comparison of the price of the goods and their marginal utility. However, unlike the private sector, the prices of public goods are not well known. When citizens vote to spend a given amount on a new sewage treatment facility, they face not a single price representing their share of total costs, but some probability function where the arguments of the function are probabilities assigned by the voter to alternative financing schemes which might be used by the municipality. In short, the typical voter is engaged in a process of maximizing under uncertainty. Consider the following voter: childless and socially unconscious, educational expenditures possess no positive utility for him; a property owner, he derives negative utility from increases in the property tax. Clearly, if the sewage treatment plant under consideration has some positive utility for him, his vote on the issue of total municipal funds to be allocated to the project will depend upon whether he anticipates funding through cutbacks on education or through tax increases. In short, the voter makes his decision without being certain as to the personal cost to him of that vote.

Consider now the alternative municipal financing schemes which constitute the arguments of the price probability function discussed above. Local municipalities have two basic options in financing new projects: increasing government revenue or cutting back other expenditures (substitution). There are, in turn, six revenue sources available to local governments: the property tax, the corporation and income tax, licenses and permits, fines and forfeits, grants and gifts, and commercial revenue. Of these six, the property tax is the most realistic source of new revenue for water pollution abatement programs. The corporation and income tax, and grants and gifts are exogenous to the local decision maker; licenses and permits, and fines and forfeits, while endogenous, each comprise less than 1 percent of the typical local budget; commercial revenue is both endogenous and relatively large; however, in general, it is used by government strictly to cover direct costs of the local service offered, rather than as a more general revenue raising venture. On the revenue side, then, the typical municipality can raise new revenue only by increasing the property tax rate.

In line with the above, the before-the-vote anticipated price of a new sewage treatment facility faced by any individual voter may be written as:

2.4 $$p^* = q_1 (r \cdot A) + q_2 (U_1) + q_3 (U_2) \ldots$$

where $q_1 \ldots . q_n$ = probabilities and sum to 1

r = property tax rate
A = land value owned by the voter
U_i = loss of utility from the expected reduction in expenditure i as a result of the sewage treatment plant construction.

If B is equal to the benefits to the voter in question from from the sewage treatment plant (or his expected benefits), then the vote of any individual depends only on whether B-p* is positive (yes vote) or negative (no vote).

B-p* is relevant to the level of government expenditures in all of the models discussed in Section 2.1. However, the way in which B-p* enters the local decision process and, therefore, influences expenditure levels depends upon the type of voting model specified.

Consider first the one man/one vote model under either individualistic or organismic motive assumptions. <u>If the</u>

Benefit function, B, is independent of the arguments of the loss function p*, then, in general, the more evenly taxes and public services are distributed, the lower will be the new sewage treatment expenditures. This result depends critically on the irrelevance of intensity of preferences. For all of those people who share in neither the tax burden nor in the benefits of alternative expenditures, p* will equal zero, and net benefits will clearly be non-negative; in short, they will vote yes. People, in sum, will consume more of a public good if they themselves do not have to pay for it.

The analysis of distributional effects becomes somewhat more complex if the benefits from the new expenditure depend upon some of the same variables that enter into the loss function. I discuss this problem below.

Given the importance of the property tax in the local budget, it is reasonable to use the ratio of property owners to total population as a proxy for the distribution of taxes.

The role of the property tax in the decision process is particularly interesting. Property ownership may be expected to have a dual effect on expenditure votes for pollution abatement facilities. First of all, as can be seen from equation 2.4, as long as q_1 does not equal zero, owning property increases the anticipated price of the new project to the voter. However, the new sewage treatment project also influences property values; the extent of this effect depending on the proximity of the property to the to-be-cleaned-up river. In short, I suggest that expenditures on sewage treatment plants are not a pure public good, in the sense that some of the benefits from such expenditure are appropriable by the people who pay for it (i.e. the property owners). This incomplete separation of the benefit and loss functions affects our expectations as to the effect of the property distribution on the level of expenditures in a town.

Consider the determinants of the vote of the property owner. It is true that the typical property owner is multidimensional: he may have children and, thus, care about the level of local educational expenditures; a sick mother-in-law and, thus, care about the level of medical expenditures; and so on. However, insofar as these effects are not systematically related to property ownership, we can abstract from them in the pure property owner vote analysis. In general, we would expect the economic and demographic terms identified to pick up the property owner's non-property related preferences.

If we consider the property owner qua property owner, it is clear that his vote will depend upon the expected increase in the market value of his property resulting from the new sewage treatment plant construction weighed against the expected property tax increase.

A variant of equation 2.4 can be used to evaluate the effect of property on voting behavior. This general part of the analysis is applicable to the property owner's vote under any and all of the decision models discussed in Section 2.1. The expected property related cost of the new expenditure on sewage treatment facilities to the property owner is:

2.5 $$C^* = q_1 (r \cdot A) + q_2 (M)$$

where q_1, q_2 are probabilities

$q_1 + q_2 = 1$

r = effective property tax rate
A = market value of property owned
M = market value of land lost by foregoing other public projects to finance the new water facility.

Then, if B is equal to the total increase in the market value of property produced by the new treatment facility, the net benefits in property value to the property owner will be:

2.6 $$NB = B - C^*$$

It should be clear from this that both B and C* depend upon ownership of land. Thus, we have no assurance that property distribution and expenditure levels will be negatively correlated. A similar problem might arise in the evaluation of expenditures on highways or other capital improvements in a town; the evaluation of educational expenditures on the other hand escapes this problem, since there is no evidence that number of children and property ownership are in any way related.

In a one man/one vote model, the politician chooses a level of expenditures by weighing the number of people for whom B is greater than $\bar{C}^*$ against the number for whom B is less than C*. In an interest group model, on the other hand, the politician is concerned with approximately maximizing $\sum_i (B_i - C^*_i)$.

Consider now the effect of the amount of land owned by individuals on the level of expenditure decision under the two voting models.

Assume first that all the land owned by any individual is equidistant from the river, so that <u>for any individual</u>, the new facility confers equal benefits on each tract of land that he owns. This assumption, while not critical to the analysis, simplifies it considerably. Assume further that the marginal utility of income is constant for any individual. Thus, benefits are strictly proportional to the amount of land owned. We can then express the net benefits of the new expenditure to the property owner in per dollar of land owned terms:

2.6 $$NB/A = B/A - q_1 \left(\frac{rA}{A}\right) - q_2 \left(\frac{M}{A}\right)$$

Since $\bar{B} = cA$, we can rewrite 2.6 as:

2.6' $$nb = c - q_1 (r) - q_2 \left(\frac{M}{A}\right)$$

In order to evaluate 2.6', we must consider likely forms for q_2 (M). Three cases come to mind.

<u>Case 1:</u> $q_2 = 0$. Here the property owner expects the full cost of the new facility to be met by property tax increase. In this case, 2.6' becomes:

$$2.6'' \qquad nb = c - q_1 \, (r)$$

In a one man/one vote model, the politician is concerned only with the sign of NB (or nb·A). In Case 1, it is clear that, since A must be positive, and nb is independent of A, the sign of NB and, hence, the property owner's vote, must also be independent of A. It should also be clear that, since the magnitude of NB varies directly with A, A, or the amount of land owned, will be very relevant to an interest group or intensity-sensitive voting paradigm.

<u>Case 2:</u> $M = dA$

and

$q_2 \neq 0$

Here, the construction of a new sewage treatment plant is done at the expense of a second project which could also be expected to increase property value in a linear way.[23] In this case, 2.6' becomes:

$$2.6''' \qquad nb = c - q_2 \, (r) - q_2 \, (d)$$

---

[23]The analysis which follows depends upon there being no intercept term in the M function. Since M by definition relates only to property-related changes, the specification of a zero intercept is appropriate.

Once again, as in Case 1, nb is independent of A, and the amount of land owned by the voter is relevant only in an interest group model.

<u>Case 3:</u> $q_2 \neq 0$
and
$M = dA^{\alpha} \quad \alpha \neq 1$

In this situation only, the amount of land owned is relevant to the sign of the vote, as well as its magnitude, and, therefore, affects the politician in a pure democracy, as well as one operating under interest group rules. However, since both M and B are monotonic functions of A, they will intersect at only one point. We can analyze this intersection point somewhat more rigorously. Under the Case 3 formulation of M, the net benefits are:

2.6'''' $\quad nb = c - q_1 r - q_2 dA^{\alpha - 1}$

The term $q_2 d A^{\alpha - 1}$ will always be positive. Therefore, since it is subtracted in the above equation, it will always give a negative contribution to the net benefits. Now there is a possibility that $c - q_1 r$ is itself negative, so, in this case, the net benefits will be negative for all A, and the non-linear term will not change the sign of the vote.

For $c - q_1 r$ positive, the net benefit may be positive in one part of the domain (acreage) and negative in another (the critical point being the intersection of the line

$(c - q_1r)A$ and the curve $(dq_2\ A^{\alpha})$. However, without knowing the value of A at which the sign of nb reverses, it is still possible to make some observations about the sign of nb if it is known at some point, based on the shape of the curve $dq_2\ A^{\alpha - 1}$. For example, if the sign of the vote is known for some small A, it is sometimes invariant for larger values.

For $\alpha < 1$: nb is negative before the intersection A_0 and positive for all $A > A_0$, so if at any point nb is positive, you know that it will continue to be positive

Similarly, for $\alpha > 1$: nb is positive for A less than the intersection point A_0 and negative for all $A > A_0$, so if at any point nb is negative, you know that it will continue to be for larger A.

The amount of property owned, then, is relevant to the sign of the vote (and, therefore, to the level of expenditure decision of the politician in the pure democracy model) only in one of the three possible cases; and even here the relevance of A is quite limited. This analysis suggests that, under one man/one vote assumptions, only the fact of property ownership and not the quantity of property owned is relevant to the level of government expenditures chosen. On the other hand, since the intensity of a voter's preferences on expenditure levels depends not only on the sign of NB, but on its magnitude, the market value of property is critical to an interest group formulation of the voting process. Thus, one way operationally to differentiate between the interest group and purely democratic models is to include the market value of property in a regression based on the former and to exclude it from the latter. The extent to which the market value term is significant should give us some idea as to the importance of each of the two voting paradigms.

The role of industrial property also differs depending upon whether interest groups or pure democracy is the voting rule. In an analysis predicated on the interest group model, the market value of industrial property is critical[24]; industry forms a basic interest group, and the effect of municipal budgetary policy on profits is one of the foundations of its vote. Industrial property can be treated somewhat differently than the residential property discussed above. From the perspective of the industry as a profit maximizing organization, there are likely to be few benefits associated with new sewage treatment facilities. On the other hand, since industry does pay property taxes, the loss from such new expenditures is likely to be considerable. Thus, in an interest group model, to the extent that industries form a viable,

---

[24]Market value of industrial property was similarly included as an interest group term in Otto Davis and G. H. Haines, "A Political Approach to a Theory of Public Expenditures", National Tax Journal, Vol. XIX, No. 3 (September, 1966), pp. 259-275. However, the analysis used in this work differs considerably from that used here.

active group, the value of industrial property in an area is likely to decrease the expenditures made on water pollution control in an area.[25]

On the other hand, the value of industrial property is irrelevant to the level of expenditures selected under rules of pure democracy. If the controllers of the industrial property are not residents of the area, they have no vote; if they are voters, then following the analysis of residential property, only the fact of their ownership and not the magnitude of the property owned counts.

The economic and demographic variables identified thus far are relevant to both the adding machine and the organismic state theories. In the adding machine model, these variables constitute the core of expenditure determination; in the organismic state model, these variables act as a constraint on the growth maximizing behavior of the political actor. One way then to differentiate between the two models is to find a proxy to measure the effectiveness of the voting constraint in the latter. In the work in Industrial Organization, the extent to which the firm is constrained to maximize profits is captured by the economic market power of that firm; by

[25]We would not expect the industrial property to have a depressing effect on all expenditures. A number of municipal services improve the profits of the firm; thus, the vote of the firm would depend on the extent to which the property tax increase produced by the new expenditure is compensated for by these pecuniary benefits.

analogy, the importance of the voting constraint on government behavior in the organismic political model can be summarized by a political market power term.

The first systematic effort to incorporate some notion of political competition into an empirically oriented model of the budgetary process was made by John Fenton.[26] Fenton, in a study of interstate government revenue and expenditure variation, found that active political party competition increased the share of government programs directed at the poor.

Fisher later adopted the Fenton indices in his study of the determinants of inter-area variance in general expenditure levels undertaken by government.[27] In Fisher's regression, political competition was found to be inversely related to the level of expenditures chosen by an area. This result is consistent with the growth or utility maximizing analysis above, although Fisher himself leaves the underlying decision model of government in his work unspecified.

A further example of the use of political competition as a variable in an expenditure determination model is provided by the work of Jackson.[28] Jackson uses political plurality

---

[26]John Fenton, "Two Party Competition and Governmental Expenditures", Paper presented at the American Political Science Association annual meetings, September 5-8, 1962.

[27]Fisher, <u>op. cit.</u>

[28]John Jackson, "Politics and the Budgetary Process", <u>Social Science Research</u>, Vol. 1, No. 1 (April, 1972), pp. 35-60.

and an election year dummy to help explain intertemporal variation in revenues and expenditures in Cleveland. Jackson's results provide further confirmation of the organismic state hypothesis.

The adding machine state and the organismic state are operationally distinct only to the extent that the voting constraint of the latter is not binding. Thus, if politicians are really growth or utility maximizers rather than vote maximizers, we would expect, once we control for the differences in community preferences, that the level of political competition would be inversely related to the level of expenditures undertaken. If, on the other hand, the true model of voting is Buchanan's adding machine state, then political competition levels should have no effect on levels of expenditures chosen. Notice, in the Buchanan model, community preferences exert a stronger influence on expenditure determination than in the organismic model; in fact, in the Buchanan model, community preferences in themselves dictate expenditure patterns.

In summary, in the next chapter of this study, I will test the four models of the determination of the level of expenditures made by local governments on water pollution control: adding machine-pure democracy, adding machine-interest groups, organismic state-pure democracy, and organismic state-interest groups. The distinction between interest group models and pure democracy models will be made by the inclusion of a regression based in the former model of variables reflecting the intensity of preferences of property holders in an area; the organismic and adding machine states will be differentiated by the inclusion of a political competition variable in the regression based on the former model.

The aim of the next chapter is two-fold. First, I am concerned with estimating the relative importance of community preferences vis à vis technical and legislative constraints in determining sewage treatment plant expenditures; economic and demographic attributes of a town are used as proxies for preferences. Estimates of the relative contribution of local preference variables are made under the four alternative specifications of government decision-making. Secondly, to the extent that it is demonstrated that local preferences do matter, I am concerned with identifying the <u>way</u> in which they matter. In particular, by testing the four decision models, I hope to shed some light on two questions in this area which I believe are important both in terms of evaluating the results of policy and of changing that policy:

(1) Are politicians sensitive to interest groups--and, in particular, property owner interest groups--in setting water pollution abatement expenditure levels?

(2) Do the growth goals of decision makers mitigate the influence which local preferences exercise in determining expenditure levels?

Contrasts between the estimates generated by the pure democracy and interest group models are directed toward the first question; contrasts between the adding machine model and the organismic model are directed toward the second.

3. Econometric Evidence on the Determinants of Local Government Expenditures on Water Pollution Abatement

Water pollution control facilities are financed by federal, state, and local governments. The first task of the burden allocation analysis then was to allocate costs among these three levels of government. Two pieces of federal legislation were relevant for this work: The Federal Water Pollution Control Act of 1956, as amended, formed the basis of the allocation of historical costs; the Federal Water Pollution Control Law of 1972 (the "Muskie Bill") was used to predict patterns of allocation for future projects.[1]

Under Section 8 of the amended 1956 statute, the federal government agreed to pay between 30 percent and 50 percent of the total construction costs of sewage treatment plants; the federal share guaranteed under this act varied according to the state's willingness to contribute to the project.[2] Under Section 202 of the new Muskie Bill, the federal share is somewhat larger: up to 75 percent of construction costs are now paid for by the federal government. A need formula is used to determine the precise share.

---

[1]The Muskie Bill guidelines were also used to modify historical allocations. Section 206 of the bill allowed for additional federal payments for facilities built prior to 1972; payments consist of up to 75% of construction costs of projects initiated between 1966 and 1972 and up to 30% of the costs of projects started between 1956 and 1966.

[2]The federal share of total construction costs went as high as 50% if the state involved agreed to contribute at least an additional 25%.

State contributions to costs of construction also vary: New Hampshire, for example, contributes 20% of the financing charges of bonds floated by municipalities to finance construction of facilities. Massachusetts provides no comparable aid in absorbing finance charges, but is somewhat more generous than New Hampshire in providing initial funds.

All operating and maintenance costs of sewage treatment plants are borne by local municipalities.

The total capital costs of construction of new treatment plants budgeted by our towns in the present period is given in Table 3.1. For most of the towns in the study area, no previous expenditures on treatment plants were made. For those towns which did have previous expenditures, the present value of these former expenditures was added to the current allocated costs.

In this chapter, I test the four models of water pollution abatement decision-making discussed in the previous chapter. The dependent variable in the regressions is the per capita expenditure budgeted for the <u>local</u> share of the capital costs (plus interest) of sewage treatment facilities. I concentrate on these capital costs rather than on annual amortization figures because these capital costs constitute the initial decision variable, whereas amortization costs simply represent the budgetary <u>result</u> of that decision. The use of a per capita figure reflects my concern with costs to individuals, rather than costs to towns.

TABLE 3.1

Capital Costs of Sewage Treatment Plant Construction

The Merrimack Basin

TOWN	LEVEL OF EXPENDITURES	TOWN	LEVEL OF EXPENDITURES
Alton	$ 625,000	Laconia	$ 673,724
Andover	640,000	Lancaster	225,000
Bedford	104,220	Lawrence	4,768,000
Belmont	112,756	Leominster	2,248,000
Billerica	278,200	Lowell	2,818,000
Boscawen	113,582	Lunenberg	1,274,000
Bow	127,039	Manchester	1,535,040
Chelmsford	948,000	Meredith	131,458
Claremont	300,000	Merrimack	2,423,333
Concord	1,537,961	Methuen	1,968,000
Dracut	552,500	Milford	1,229,110
Fitchburg	6,440,000	Nashua	2,100,480
Franklin	329,990	New London	540,000
Gilford	145,707	North Andover	624,000
Goffstown	275,942	Northfield	93,180
Gorham	270,000	Pembroke	1,090,000
Groveland	320,000	Peterborough	950,559
Haverhill	2,880,000	Pittsfield	840,000
Henniker	370,000	Plymouth	75,000
Hillsboro	375,000	Sanbornton	46,195
Hinsdale	690,000	Tewksbury	681,500
Hooksett	388,888	Tilton	116,730
Hopkinton	380,000	Warner	230,000
Hudson	144,000	Westminster	212,000
Jaffrey	97,500	Wolfeboro	175,000

The models estimated are given below. It should be noted that I have specified a multiplicative rather than an additive functional form. In particular, it seems most reasonable that the effect of changes in any one of the independent variables specified on the expenditure level of an area depends upon the value of the other variables. Thus, a town which is close to the river is likely to react more strongly to income increases than is a town far from the river. Similar interaction seems to exist between the rest of the variables specified as well.

Equation 1. Adding Machine-Pure Democracy

$$X = aY^{B_1} D^{B_2} N^{B_3} S^{B_4} G^{B_5} T^{B_6} C^{B_7}$$

Equation 2. Adding Machine-Interest Groups

$$X = aY^{B_1} D^{B_2} N^{B_3} S^{B_4} G^{B_5} T^{B_6} C^{B_7} MIS^{B_8}$$

Equation 3. Organismic State-Pure Democracy

$$X = aY^{B_1} D^{B_2} N^{B_3} S^{B_4} G^{B_5} T^{B_6} C^{B_7} POL^{B_8}$$

Equation 4. Organismic State-Interest Groups

$$X = aY^{B_1} D^{B_2} N^{B_3} S^{B_4} G^{B_5} T^{B_6} C^{B_7} POL^{B_8} MIS^{B_9}$$

where:

X = per capita level of expenditures on water pollution abatement

Y = per capita median income

D = population density

N = river miles in a town divided by town area

S = per capita waste discharge (municipal + industrial)

G = percentage of total costs provided by federal and state government

T = previous year's tax rate divided by median income

C = distribution of town property

MIS = proxy for value of town property to owners

POL = political competition in a town

For the most part, the variables defined above follow directly from the analysis in Chapter 2. However, C, MIS, and POL require some additional discussion.

In Chapter 2, I suggested that property ownership was an important factor in shaping voter preferences about optimal government expenditure levels. I also indicated that there were two dimensions of property ownership which should be considered. First, for a one man/one vote case, only the fact of ownership and not the more elusive magnitude of property owned is relevent to the vote. In this study, C is used to reflect this ownership-nonownership aspect of the property question. In an interest group analysis, on the other hand, the amount of property owned also becomes critical; MIS was used to reflect this value dimension of property.

Consider first the proxy used for C. There are three groups of property holders in a typical town: homeowners, landlords, and business property holders. There is no data available which can tell us the number of landlords and business property holders relative to the total population of a town. However, we do have data on the relative number of homeowners. If we assume that landlords and businessmen are either (1) not voting residents in a town and, thus, excluded from the base population; or (2) voting residents who also own their own homes and, thus, included already in the home ownership data; then we can use home ownership data by itself to reflect property ownership in a town. Following this reasoning, C was set equal to the number of homeowners in a town divided by the total population in that town; if the above assumptions are reasonable, then, as C increases, the relative number of property owners in a town should also increase, and property-related factors should become increasingly important in establishing the town budget. It should be noted here that, as a result of some interesting characteristics of water pollution abatement expenditures, the expected sign of C is unclear. As I suggested in Chapter 2, Both the benefits and the costs of water pollution expenditures depend upon whether or not the individual owns property.

In particular, if the expected property value increase generated by the water pollution abatement expenditure exceeds the expected property tax increase used to finance this expenditure, then we would expect property ownership to be positively related to expenditure levels; conversely, if the tax effects dominate, we would expect C to be negative. Thus, the econometrics generated in this study should provide an assessment of the relative strength of these two effects.

The variable MIS is designed to capture the intensity of preferences of property owners and, thus, is included only in the interest group based regressions. The usual approach is to use the percentage of all residential property in a town as the basic interest group variable;[3] this approach assumes that, as the percentage of residential property of a town decreases, the proportion of any property tax increase generated by shifts in government expenditures which will be absorbed by voting residents also decreases. Thus, the lower the percentage of residential property in an area, the smaller will be the costs of government expansion to voters. Residential property in this conventional formulation consists of both home owned and rental housing. In this study, I have excluded renters from the property interest group. MIS

---

[3] Glenn Fisher, "Interstate Variation in State and Local Government Expenditures", National Tax Journal, Vol. XVII, No. 1 (March, 1964), pp. 57-74.

is instead set equal to the percentage of the total value of property in a town which consists of owned homes. Participating in an interest group involves certain costs; in particular, there is the cost of information (viz. what group do I belong to?) and the costs of participation. Only if the expected loss from an adverse vote is greater than the sum of these two costs will voters form a viable interest group. I would argue that (1) the costs of information are higher to the renter than to the owner, given the more indirect nature of the tax increase on rents in the case of the former; and (2) expected losses from tax increases are smaller to the renter than to the owner. This latter effect is attributable to the fact that it is only in the long run that renters pay the tax increase; the long run being defined as the time it takes landlords to leave the area. This may be quite long indeed. Thus, in this study, renters are excluded from the MIS variable on the grounds that their expected interest group participation is considerably lower than that of homeowners. It might be noted here that several studies of community reactions to new transportation projects found a similar difference in the propensity of renters and homeowners to join interest groups.[4]

---

[4]Bruce Bishop, Clarkson Oglesby, and Gene Willeke, "Community Attitudes towards Freeway Planning", in Highway Research Record, No. 305 (Washington, Highway Research Board, 1970), pp. 41-52.

The organismic and adding machine models of the state are distinguished by the inclusion in the former model of a variable which is intended to reflect the level of political rivalry in a town. In the Fenton analysis and in subsequent work on political competition as a determinant of expenditure levels, political competition was defined along party lines. That is, the proxy variable was a measure of the strength of Republicans versus Democrats. This party-oriented analysis is less useful for this study of local New England elections. A substantial proportion of the elections we are considering are nonpartisan; moreover, even in those elections in which party politics operate, issues are sufficiently local that party affiliation is not critical. In this study, two alternative specifications of political competition are used.

First, I defined political competition as the ratio of actual turnover in elected town officials to the maximum turnover possible during the ten years prior to the pollution expenditure decision. Thus, if a town mayor serves a two-year term, the maximum turnover in our study period is 4. The POL(1) term in regressions 3 and 4 thus varies from zero to one, with higher values signifying more competition. If our hypothesis on the nature of the decision process is correct, the coefficient on this variable should be negative.

The POL(1) variable described above, however, is somewhat inadequate: it does not differentiate between towns in which an incumbent wins an election unopposed and one in which he wins only after a hard battle with some political challenger, even though the implicit competition in the two cases is quite different. This is a problem similar to the one faced when we use simple concentration ratios in Industrial Organization as a measure of market power. That is, we can measure only the extent to which firms successfully challenge market leaders, and not how hard they try. As Bain[5] indicates, this latter aspect may well exert a strong influence on the extent to which market power may be used. Similarly, I would argue that the existence of active challengers in political elections restrains the budgeting behavior of the incumbent, even if these challengers have been unsuccessful in the past. The POL(2) variable, in equations 5 and 6, is an attempt to deal with this issue of potential competition. In this variable, political competition is measured by the plurality of the elected town official in the election prior to the expenditure decision. Thus, the higher is POL(2), the lower the political competition; the original hypothesis suggests that POL(2) should have a positive coefficient.

Using econometric evidence to differentiate among the four models outlined in Chapter 2 is a very difficult task.

---

[5] Joe Bain, Barriers to New Competition (Cambridge, Harvard University Press, 1956), Chapter 1.

The models are all quite complex, and the sample size in this study is, unfortunately, not very large. Thus, I believe the real test of the validity of each of the models is to be found in their internal consistency, and the extent to which they mesh with our priors. Nevertheless, some information is provided by these regressions on the viability of alternative decision models; the results are more interesting, however, in terms of what each of the models predicts concerning the relative importance of various economic and demographic variables in water pollution expenditure decisions.

The six equations below were estimated by ordinary least squares. Two specifications for political competition are presented.

All of the variables in the six regressions are of the right sign, although several are not significant. Standard errors are provided in parentheses under the coefficients. A list of those variables which are significant at the .05 level is provided in Table 3.3. Several interesting conclusions emerge from these estimates.

The first question posed in this study was the extent to which community preferences, as reflected in the economic and demographic variables defined, account for intermunicipality variance in water pollution abatement expenditures. The estimates provided in the six equations below suggest that slightly more than 35 percent of this intertown variance

TABLE 3.2

Regressions Explaining Inter-town Variations in Per Capita Capital Expenditures on Sewage Treatment - O.L.S.

Equations	Y	D	N	S	G	T	C	MIS	POL-1	R^2
1										
D - AM	2.1967	-.5039	.1119	.0654	-.4733	-.0115	-2.010			.4008
	(.7981)	(.1137)	(.0577)	(.1789)	(.2244)	(.4309)	(.8525)			
2										
I - AM	2.6222	-.4744	.0904	.0836	-.5327	+.3556	-1.7124	-.3879		.4142
	(.8892)	(.1167)	(.0610)	(.1794)	(.2307)	(.5486)	(.8948)	(.3597)		
3										
D - O	2.2177	-.4915	.0939	.0512	-.4721	.0838	-1.9136		-.1997	.4087
	(.8010)	(.1150)	(.0619)	(.1803)	(.2251)	(.4474)	(.8631)		(.2424)	
4										
I - O	2.6372	-.4631	.0727	.0695	-.5307	.4440	-1.6220	-.3828	-.1952	.4217
	(.8924)	(.1180)	(.0648)	(.1809)	(.2315)	(.5613)	(.9048)	(.3610)	(.2421)	

Equations	Y	D	N	S	G	T	C	MIS	POL	R^2
5										
D - O	1.4796	-.37222	.14266	.14667	-.41963	-.17190	-1.3307		1.1225	.4607
	(.8218)	(.1222)	(.0568)	(.1746)	(.2162)	(.4183)	(.8651)		(.4716)	
6										
I - O	1.9738	-.32422	.11739	.16439	-.49228	-.29049	-.89225	-.50186	1.2107	
	(.8807)	(.1252)	(.0558)	(.1739)	(.2195)	(.5212)	(.9070)	(.3442)	(.4704)	.4827

TABLE 3.3

Significant Variables

Equation	Variables Significant at .05 Level
1	Income Population density River miles per acre Other govt. expenditures Homeowners per pop.
2	Income Population density Other govt. expenditures
3	Income Population density Other govt. expenditures Homeowners per pop.
4	Income Population density Other govt. expenditures
5	Population density River miles per acre Other govt. expenditures Political competition
6	Income Population density River miles per acre Other govt. expenditures Political competition

can be explained by this set of preference variables. Thus, despite relatively stringent federal regulations and standards, individual towns retain significant flexibility in determining their sewage treatment plant expenditures.

Consider now the relative importance of each of these preference variables.

From the perspective of the overall thrust of this study, the high and significant per capita income coefficient is particularly interesting. Since the functional form of the equations is log-log, the income coefficient gives the income elasticity of water pollution abatement expenditure. Thus, the results suggest an income elasticity of per capita water pollution abatement expenditures of between two and three; if a town has a ten percent higher median income than a second town, it is <u>ceteris paribus</u> likely to spend between 20 and 30 percent more <u>per capita</u> on water pollution abatement. In all likelihood, then, and contrary to recent hypotheses,[6] water pollution expenditures do not increase between-town real income differentials. Lower income towns can and do choose lower water pollution abatement levels.

A second preference variable is the distribution of property ownership, variable "C" in the above equations. All

---

[6] Nancy Dorfman, <u>Who Bears the Cost of Pollution Control?</u> (Washington, D.C., Council on Environmental Quality, August, 1973).

four regressions indicate that the percentage of voters in a town who are also property owners has a negative and large effect on the level of sewage treatment expenditures undertaken by that town; the estimated elasticity of these expenditures with respect to property ownership is between 1.5 and 2. The negative sign of C suggests that political leaders believe that property owners are more sensitive to tax increases than to any property value increases resulting from river improvement. It should be clear here that this coefficient is a measure only of the political perception of voter preferences and does not necessarily reflect the actual impact of pollution abatement on taxes vis à vis property value. The extent to which property owners in fact prefer lower water pollution abatement expenditures than do renters will be explored in Chapter 5.

The third and last preference variable included in the regressions is the N, the proximity of the study town to the river. This variable, too, proved to be significant in most of the specifications. This suggests that riverside towns which anticipate high potential benefits from clean water are most willing to pay for that clean-up.

Three variables were used to represent technical constraints on water pollution abatement expenditures: population density, waste discharged, and program contributions by federal and state government.

Population density is negative and significant in all of the equations specified; a 10 percent increase in population density produces approximately a 5 percent decrease in per capita expenditures. This result is consistent with the hypothesis that economies to scale exist in the provision of certain public goods. The technical engineering literature suggests that these density effects are particularly important in the construction of interceptor pipes, which constitute a fairly significant segment of the total sewage treatment plant costs. The negative elasticity suggests further that sparsely populated rural towns may well be disproportionately affected by federal water pollution legislation.

Increases in the expenditures by state and federal government on local water pollution abatement facilities result in a decrease in the price of those facilities to towns. As the estimates indicate, the effect of these increases in the share financed by other governmental units is to decrease the total town expenditures on these facilities. Since the elasticity of these expenditures is less than one, the overall effect of increases in federal and state expenditures is to increase the total (i.e. federal + state + local) sewage treatment expenditures, while simultaneously decreasing the local share.

The waste variable is not significant in any of the specifications. This may in part be a reflection of problems of measuring this variable.

MIS is an additional preference variable used to discriminate between the pure democracy and interest group models. While the variable is of the right sign (viz. negative as is C), it is not highly significant. The inclusion of this variable does, however, improve the corrected R^2 of our equation. Thus, only very minimal support for an interest group model of local government decision making is provided by this study.

Political competition seems to be a more fruitful addition to the set of community preference variables. Both specifications of political competition are of the right sign: POL(1) is negative, and POL(2) is positive. Moreover, the second variable specification is quite significant. Thus, the work done here suggests that, unless political competition is fairly strong at the local level, community preferences may be to some extent overridden by the growth preferences of local decision makers. Clearly, the empirical results generated in this study suggest that additional work in the area of the organismic model of the state may prove quite fruitful.

In summary, the empirical work in Part 1 of this study has generated two primary conclusions. First, community preferences do explain a significant part of the intermunicipality variance in water pollution abatement expenditures. In particular, town income levels, proximity to the river, and the dispersion of property ownership are the three most important of these preference variables. Secondly, the extent to which these preferences are reflected in budgetary decisions is a function, not only of technical constraints and federal requirements, but also of the level of political competition in an area.

The estimates generated above will serve two additional functions in the second part of this study. First, given the successful performance of the political competition term in predicting expenditure levels, I will attempt to use this variable to explain the differences in the mechanisms chosen by different municipalities to finance their pollution abatement expenditures. In particular, in Chapter 4, I will consider the extent to which political competition encourages the use of expenditure substitution as opposed to increased property taxation as a way to finance new water pollution abatement programs. There is a further use to which the estimates generated in this first part will be put. In particular, in Chapter 5, I consider the extent to which an individual's willingness to pay varies with income, property ownership, and proximity to the river. By comparing the demand elasticities generated by this individual benefit survey with the elasticities provided by the cross-sectional town date, a primitive sense of the extent to which community preferences are correctly perceived in the political process is provided.

PART II:

The Incidence of Costs and Benefits of Water Pollution Abatement

4. The Distribution of Municipal Costs of Water Pollution Abatement Programs Among Income Classes

In Part 1, Chapters 2 and 3 of this study, I examined the determinants of intermunicipality variance in sewage treatment plant expenditures. In this chapter and in Chapter 5, I consider the effect of these expenditures on the distribution of income in the study area.

4.1 Financing Methods Used: Assumptions and Estimates

In order to determine the incidence of water pollution expenditures among income classes, we must estimate, not only the absolute level of those expenditures, but also the way in which these expenditures are to be financed. Previous studies on this issue have assumed that such expenditures are financed exclusively from property tax increases;[1] clearly, making this assumption is a second best approach to the incidence question. In this study, I attempt to determine the source of pollution abatement funds more precisely.

As discussed earlier, local governments have two basic methods of raising funds for new expenditures: they can increase the property tax, or they can reduce other expenditures. The choice between the two has important implications for the way in which incidence is analyzed. If the total expenditure is to be financed via a property tax increase, then net incidence can be found by comparing the distribution of property taxes among income classes with the distribution of water pollution abatement benefits. If, on the other hand, the new expenditures are to be made at the expense of some old expenditure, then incidence depends on the distribution of benefits from the now foregone expenditure.

---

[1] See, for example, Nancy Dorman, "Who Pays for Water Pollution Abatement?", a PIE-C study, 1973.

Strictly speaking, it is inappropriate simply to look at what happens to town budgets once the new pollution abatement expenditures are introduced. Instead, the actual town budget should be compared with what we believe the budget would have been in the absence of pollution expenditures. In more technical terms, the primary emphasis should be with differential rather than specific incidence.[2]

In the absence of a reliable crystal ball, we are forced to estimate differential incidence indirectly. Two complementary estimation techniques are used in this study: the hypothetical budget method and the analysis of variation of town expenditures technique. Explanations of the operation of these two techniques, as well as the results generated by applying each technique to the problem of estimating the source of water pollution abatement funds, are discussed in Sections 4.1.1 and 4.1.2 below.

4.1.1 The Hypothetical Budget Method

One technique for estimating differential incidence is to compare the actual with-pollution expenditure town budget with a hypothetical budget constructed assuming that no pollution abatement expenditure occurred. In this study, this hypothetical budget is constructed by extrapolating the

---

[2]For a more detailed treatment of the differences between differential and specific incidence, see Richard Musgrave, The Theory of Public Finance (New York, McGraw Hill Book Company, Inc., 1959), Chapter 10.

historical tax and expenditure levels of study towns according to some assumptions about budget growth rates. This estimated public budget is then compared with the actual budget to determine the source of pollution abatement funds. If actual spending for non-pollution abatement control items is equal to or greater than forecasted levels, then we will assume that expenditures are not being curtailed, but instead that pollution control is being property tax financed. Conversely, if actual spending is less than the forecast, we will conclude that spending cuts have been made. This process provides an estimate of the extent to which a town relies on tax increases or expenditure substitution to finance sewage treatment; these source-of-funds estimates can then be used in conjunction with previous work on tax and expenditure incidence to allocate pollution abatement costs among income classes.

Clearly, the results generated by this technique depend heavily on the choice of assumptions made about the growth over time in town taxes and expenditures. Hence, in this study, two distinct growth path assumptions are made in order to illuminate the range of possibilities.

In most of the towns in New England, school expenditures are decided separately from other town expenditures and are presented to town officials as given. Thus, in this study, educational expenditures are not treated as a potential source of new pollution abatement funds. Instead, I assumed that these expenditures were exogenous to the town budgetary decision.

In developing this incidence analysis work, data from two large towns in the basin area was used: Nashua, New Hampshire and Leominster, Massachusetts. Both towns financed new water pollution treatment facilities in the 1960's, and, thus, budget data is available for both the pre- and post-pollution expenditure periods.

In Table 4.1, the actual and hypothetical budgets for the two towns under consideration are presented; in lines (11) and (12), estimates of the percentage of new water pollution abatement funds financed through property tax increase are provided. The hypothetical budget, lines (7) and (8), was constructed under two alternative specifications of town budget growth paths. Assumption 1, termed the conservative path, posits a yearly growth rate in the relevant expenditure category equal to the average annual growth rate in the years prior to the pollution expenditure (1960 for Nashua, 1964 for Leominster). This assumption yields a growth rate of 6.25% in Nashua and 6.4% in Leominster. Under Assumption 2, tax and expenditure growth rates are set equal to the weighted average of growth rates in years prior to the pollution expenditure, where the weights are highest in the most recent years. This assumption generates a growth rate of 5.8% in Leominster and 9.93% in Nashua.

TABLE 4.1a

Budget Data for Nashua, N.H.

Expenditure Category	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1. General Revenue	3099	3123	3171	3291	3477	3826	4101	4861	5175	6171	6498	7240	7467	7864	8130	11030	11862
2. Property Tax	2523	2580	2579	2770	2993	3235	3457	4027	4140	4837	4938	5447	5883	6463	7310	8767	10112
3. Education Expenditure	1110	1145	1081	1307	1376	1529	1632	1870	2067	2263	2600	2856	3255	3622	3879	4805	5126
4. Treatment Facilities									100.8	102.2	254.4	256.0	257.7	260.3	261.1	262.7	264.4
5. G.R.-Ed. Exp.	1989	1978	2090	2984	2101	2297	2469	2991	3108	3908	3895	4384	4212	4242	4251	6225	6738
6. Percentage Increase		-.56	5.6	-5.1	5.9	9.3	7.5	21.24									
7. Conservative Growth Path									3178	3376	3588	3812	4050	4303	4572	4858	5101
8. Liberal Growth Path									3288	3614	3973	4367	4810	5278	5802	6379	7012
9. Actual minus Expected-Conservative									-70	-532	+307	+572	+162	-61	-321	+1367	+1575
10. Actual minus Expected-Liberal									-180	+294	-78	+17	-589	-1036	-1551	-154	-276
11. Percent Allocated to Property Tax-Conservative									0	100	100	100	63	0	0	100	100
12. Liberal									0	100	0	7	0	0	0	0	0

TABLE 4.1b

Budget Data for Leominster, Mass.

Expenditure Category	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
1. General Revenue	3414	3508	3635	4507	4976	5126	5718	6068	7313	7702	8472	8924	8806	10547
2. Property Tax		2097	2189	2286	392	2507	2647	2954	3818	3785	4125	4479	5131	6236
3. Education Expenditures	1221	1284	1344	1435	1509	1569	1800	1842	2437	2637	3008	3437	3919	4676
4. Treatment Facilities								77.8	99.7	103.4	131.5	159.3	162.0	162.8
5. G.R.-Ed. Exp.	2193	2225	2291	3071	3467	3557	3918	4225	4876	5064	5465	5487	4886	5871
6. Percentage Increase		1.46	3.00	34.00	12.89	2.60	10.15							
7. Conservative Growth Path								4169	4436	4720	5023	5345	5687	6052
8. Liberal Growth Path								4147	4391	4649	4922	5211	5516	5840
9. Actual minus Expected-Conservative								56	440	344	442	142	-801	-181
10. Actual minus Expected-Liberal								78	485	415	543	276	-630	31
11. Percent Allocated to Property Tax-Conservative								72	100	100	100	89	0	0
12. Liberal								100	100	100	100	100	0	19

The estimates provided by applying the hypothetical budget method suggest that at least some portion of water pollution abatement expenditures are financed through expenditure cut backs. The estimates further suggest that the propensity to finance new water pollution abatement expenditures through property tax increases varies considerably across towns. In particular, Leominster depends almost exclusively on property tax increases; Nashua relies somewhat more heavily on expenditure substitution. The absence of additional historical data on water pollution abatement financing for other towns in the study area makes a systematic analysis of the determinants of this variation in funding method difficult. Nevertheless, some information may be gleaned from the relative attributes of the two towns for which budget data is available.

Leominster has historically had a somewhat higher effective property tax rate than has Nashua; clearly, this reflects the tendency in Nashua to use expenditure substitution techniques, rather than property tax increases. The median income and education levels in the two towns are quite similar; thus, neither of these demand-for-public-service variables gets us very far in explaining funding variance. In Part 1, I suggested that political competition might help to explain some of the inter-town variation in the levels of expenditures on water pollution abatement. In fact, the hypothesis generated in Part 1 of this study--viz. that strong political competition helps to keep expenditure levels low--is at least consistent with the Nashua, Leominster patterns in funding water pollution efforts. In particular, during the period under study, Leominster--which depended heavily on property tax increases--had a lower level of political competition, as measured by plurality in elections, than did Nashua. Once again, the conclusion that political competition affects the extent to which towns will rely on property tax increases as the primary source of water pollution abatement funds must be regarded at this point as highly tentative; further support of this proposition depends on a considerably more comprehensive data set. Nevertheless, the conclusion, through tentative, does suggest that further work in this area may be fruitful.

Before the implications of using expenditure substitution as a means to raise new water pollution abatement funds can be explored, the types of expenditures which are most likely to be reduced in response to these new pollution abatement requirements must be determined. In the next section, some work is done on this question through an analysis of variation in town expenditures.

4.1.2 Which Expenditures are Reduced? Examining the Variance in Town Expenditures

Given the proposition that some portion of new water pollution abatement funds are financed through reductions in other local expenditures, the distributional implications of this funding source depend on <u>which</u> expenditure categories are in fact reduced. Clearly, financing water pollution abatement through reductions in public welfare expenditures has radically different distributional consequences than equivalent financing accomplished via park and recreation expenditure reductions. In this section, a preliminary attempt is made to specify the type of expenditure substitution which in fact occurs.

Disaggregating expenditure substitution is done, in this study, in two stages. First, I consider the extent to which particular town expenditures vary, both within towns over time, and between towns in any given time period. I assume that high degrees of variation in expenditures means that that particular local expenditure is viewed as a luxury by the town. In short, the greater the between-town, or across-time variation in expenditure levels, the more likely it is that the expenditure will be reduced in response to new pollution abatement requirements.[3]

In Step 2 of the analysis, the expenditure-substitutability estimates are refined somewhat. In particular, we are concerned, not only with the extent to which particular expenditures vary, but more importantly, with the extent to which these expenditures vary in responst to a particular stimuli--viz. increased burdens on the town budget. In

[3]This argument implicitly assumes that cross-town expenditure differentials reflect primarily demand differences rather than cost differences, or, more formally, that marginal value product functions vary more across towns than do opportunity costs.

investigating this issue, I depend heavily on previous work done in public finance on the determinants of variation in town expenditures.

Analysis of the budget data for the towns in the Merrimack study area suggests that the four most variable expenditure categories (excluding education) are fire, police, highways, and parks and recreation. All four expenditure categories exhibit a high degree of variation both across towns and over time. This result is consistent with similar analyses done previously.[4]

Of the four categories of expenditures listed above, which are most likely to shift in response to new pollution abatement requirements? Highway expenditures can be eliminated almost at once. Previous research suggests that variation in highway expenditures is primarily a response to variation in state and federal aid levels.[5] Of the remaining three, park and recreation expenditures seem to be most highly related to economic attributes of an area, while police and fire run a -

---

[4]See, for example, Roy Bahl and Robert Saunders, "The Determinants of Changes in State and Local Government Expenditures", in The National Tax Journal, Vol. XVIII, No. 1 (March, 1965), pp. 50-57.

[5]See, for example, L. R. Gabler and Joel Brest, "Interstate Variation in Per Capita Highway Expenditures", National Tax Journal, Vol. XX, No. 1 (March, 1967), pp. 78-85; and John Weicher, "Aid, Expenditures, and Local Government Structures", National Tax Journal, Vol. XXV, No. 4 (December, 1972), pp. 573-584.

close second.[6]

Thus, we can conclude first that some expenditure substitution does occur in response to new federal water pollution abatement requirements, and, second, that this substitution is likely to occur most often in the areas of parks and recreation and of public safety. The cost incidence of water pollution abatement programs produced by these two conclusions are discussed in the remainder of this chapter.

4.2 Tax and Expenditure Incidence

Although the estimates generated in Section 4.1 of this study suggest that property taxes are not the sole source of funds for water pollution abatement, these taxes nevertheless constitute an important source of funds for municipalities. Thus, it is important to consider which income groups bear this tax.

The property tax is a tax on four separate kinds of goods: owner-occupied housing, rental property, commercial and industrial property, and farm property.

The conventional theory suggests that, in the long run, taxes on residential property, both owner-occupied and rented, are borne by the occupant.[7] Occupants of owner-occupied

---

[6]Otto Davis and George Haines, "A Political Application to a Theory of Public Expenditures: The Case of Municipalities", in National Tax Journal, Vol. XIX, No. 3 (September, 1966), pp. 259-275; and Bahl and Saunders, op. cit.

[7]C.F. Richard Netzer, The Economics of the Property Tax (Washington, D.C., Brookings, 1966).

housing bear these taxes in the short run as well. The short-run incidence of property taxes on rental property is less clear. In particular, traditional theory argues that, since supply is inelastic in the short run, landlords must absorb the incremental tax. On the other hand, several people have recently suggested that, in oligopolistic urban rental markets, property taxes may act as a signal for landlords to raise rents immediately and, hence, shift the burden of the property tax to tenants in the short run as well.[8]

If occupants do bear the burden of the residential property tax, then this portion of the new water pollution abatement funds would appear to be regressive. Housing has an income elasticity less than 1; thus, a property tax which is proportional to the value of property will rest relatively more heavily on low- than on high-income people.[9] This regressivity of the residential portion of the property tax is exacerbated by federal income tax laws. Homeowners can deduct property tax payments from their income tax; since the monetary value of this deduction depends on the marginal tax bracket of the homeowner, the overall effect of these laws

---

[8]Helen Ladd, "The Role of the Property Tax", unpublished paper, Harvard, 1973.

[9]It should be noted that some recent work disputes this finding. If we use Friedman's permanent income rather than the usual money income, housing has an income elasticity somewhat larger than 1. See "The Demand for Nonfarm Housing", in A. Harberger, The Demand for Durable Goods (Chicago, 1960).

is regressive. In Table 4.2, the effect of these tax laws on increasing the regressivity of residential property taxes is illustrated.

The incidence of the portion of the property tax which falls on commercial, industrial, and farm realty is not quite as clear-cut as that on residential property. Traditional theory assumed that this part of the tax was similar to an excise tax and, therefore, would be shifted completely on to the consumer.[10] It, too, was considered regressive since the marginal propensity to consume declined with income. This assumption, however, has been challenged recently: the argument has been made that the tax on business property in analogous to a tax on income from capital and, therefore, will not be totally shifted forward unless the business involved is a monopoly.[11] Thus, recent work has attributed one half of the business property tax to capital and one half to consumers.

Personal property, the last object of the property tax, is, for the most part, business machines and inventory. It is assumed that this portion of the tax is shifted forward to consumers, much as any excise tax. It, too, is regressive.

---

[10] C.F. Richard Musgrave, "The Distribution of Tax Payments by Income Group", in National Tax Journal (March, 1951).

[11] Helen Ladd, op. cit.

TABLE 4.2

Incidence of Real Estate Taxes
Adjusted for Tax Deductions
1960

Income Class	Property Tax/ Income	Adjusted for Tax Savings
3,000 - 4,000	4.46	3.57
4,000 - 5,000	3.72	2.98
5,000 - 6,00	3.34	2.67
6,000 - 7,000	3.15	2.52
7,000 - 8,000	3.07	2.46
8,000 - 9,000	2.96	2.31
9,000 - 10,000	2.89	2.25
10,000 - 15,000	2.79	2.18
15,000 - 20,000	2.71	1.90
20,000 - 25,000	2.52	1.70
25,000 - 50,000	2.13	1.21

Source: Dick Netzer, Economies of the Property Tax (Washington, D.C., Brookings, 1966), p. 49. Statistics compiled from U. S. Treasury Department, Statistics of Income, Individual Income Tax Returns, 1960. Only taxable returns were used.

Table 4.3 presents the estimates of the incidence of the property tax derived from four major studies. It should be noted that all four rely heavily on the shifting assumptions described above and, thus, should be interpreted with some care.

In lieu of property tax increases, local governments can choose to raise pollution abatement funds by reducing other local expenditures. We must then consider the incidence of the benefits of those government expenditures which are reduced as a result of new water pollution abatement expenditures.

The analysis of variation in town expenditures done in Section 4.1.2 suggests that the prime targets for expenditure substitution will be parks and recreation and public safety. Expenditure incidence in general is somewhat more primitive than tax incidence; in particular, estimating incidence requires a number of not altogether satisfying assumptions. Nevertheless, in the absence of anything better, the expenditure substitution analysis conducted here must rely on the best of this work.

In Table 4.4, estimates of the incidence of natural resource expenditures by local governments and miscellaneous expenditures are presented. Miscellaneous expenditures is the most disaggregated break-down available which covers the

TABLE 4.3

Incidence of the Property Tax:
Property Tax as a Percent of Family Income

STUDY	INCOME CATEGORY									
1. Herriott and Miller	Under $2,000	$2,000-$4,000	$4,000-$6,000	$6,000-$8,000	$8,000-10,000	$10,000-$15,000	$15,000-$25,000	$25,000+		
	8.3%	5.3%	4.3%	3.8%	3.7%	3.8%	3.8%	2.5%		
2. Musgrave	Under $2,000	$2,000-$4,000	$4,000-$6,000	$6,000-$8,000	$8,000-10,000	$10,000-$15,000	$15,000-$20,000	$20,000-$30,000	$30,000-$50,000	$50,000+
	6.7%	5.7%	4.7%	4.3%	4.0%	3.7%	3.3%	3.0%	2.9%	3.3%
3. Tax Foundation	Under $2,000	$2,000-$3,000	$3,000-$4,000	$4,000-$5,000	$5,000-$6,000	$6,000-$7,500	$7,500-10,000	$10,000-$15,000	$15,000+	
	6.9%	5.2%	4.7%	4.2%	4.2%	3.8%	3.5%	3.3%	2.4%	
4. Gillespie	Under $2,000	$2,000-$3,000	$3,000-$4,000	$4,000-$5,000	$5,000-$7,500	$7,500-10,000	$10,000+			
	6.0%	6.2%	5.8%	6.9%	5.2%	3.1%	2.3%			

Sources: See following page.

Table 4.3 Data Sources

[1]Herriott and Miller, "The Taxes We Pay", Conference Board Record (May, 1971); and "Tax Changes Among Income Groups, 1962-68", Business Horizons (February, 1972).

Data from 1963 Survey of Financial Characteristics of Consumers.

Total Income = money income plus
underreported money income
imputed income
realized capital gains
retained earnings
indirect taxes (less transfers)

[2]Musgrave, Study in progress.

Data was obtained from the Brookings Institution's Merge File compiled from the 1966 Survey of Economic Opportunity and U. S. Government Tax File.

Adjusted Family Income = factor income
+ corporate profits
+ transfers
+ imputed rent
+ wage supplements
+ insurance interest
+ other accrued capital gains

[3]Tax Foundation, Tax Burdens and Benefits of Government Expenditures by Income Class (New York, 1967).

Data compiled from Bureau of Labor Statistics, Consumer Expenditures and Income, Survey of Consumer Expenditures 1960-1961. (Bureau of Labor Statistics Report No. 237-39)

U. S. Department of Commerce, Survey of Current Business (July, 1966), and Tax Foundation extimates.

Total Income = income before taxes.

[4]Gillespie, "Effects of Public Expenditures on the Distribution of Income", in Musgrave, Essays in Fiscal Federation (Brookings, 1965).

Adjusted Income = income + benefits from government + transfers - taxes.

TABLE 4.4

The Incidence of Local Government Expenditures

NATURAL RESOURCES

Income	Benefits as a % of Income
Under $2,000	6.28%
2,000 - 3,999	2.09%
4,000 - 5,999	1.46%
6,000 - 7,999	.96%
8,000 - 9,999	.80%
10,000 - 14,999	.62%
15,000 - 24,999	.44%
25,000 +	.37

Source: Herriot and Miller, op. cit.

MISCELLANEOUS

Income	Benefits as a % of Income
Under $2,000	17.1 %
2,000 - 2,999	5.6 %
3,000 - 3,999	3.1 %
4,000 - 4,999	2.0 %
5,000 - 7,499	1.2 %
7,500 - 10,000	.7 %
10,000 +	.4 %

Source: Gillespie, op. cit.

TOTAL LOCAL GOVERNMENT EXPENDITURES

Income	Benefits as a % of Income
Under $4,000	27.1 %
4,000 - 5,700	18.7 %
5,700 - 7,900	15.8 %
7,900 - 10,400	12.2 %
12,500 - 17,500	7.4 %
35,500 +	2.2 %

Source: Musgrave, op. cit.

category of public safety.[12] The incidenct of total local government expenditures is also provided. In all three categories, some regressivity is evidenced; that is, the poor benefit more than proportionately from local government expenditures. As we might expect, given the inclusion of transfer payments in the miscellaneous category, this category of expenditures appears somewhat more regressive than that of natural resources. I suspect that, if we considered public safety alone, the ordering of the two classes of expenditures would be reversed.

4.3 The Distribution of Costs Detailed

On the basis of the analysis of water pollution abatement financing sources, in conjunction with the tax and expenditure incidence work discussed above, an estimate of the incidence of pollution abatement costs may be obtained.

First, consider a situation in which the full costs will be financed through the property tax. In the Merrimack River Basin, the costs of water pollution abatement programs which will be borne by local communities is $90,000,000. If we distribute the incremental property tax required by this new program in the same proportion as the original Musgrave-estimated property tax,[13] we end up with a distribution of incremental pollution abatement costs as in Table 4.5. On the

[12]In addition to public safety, the miscellaneous category includes manpower, postal services, commercial regulation, public utilities, and transfer payments.

[13]This method implicitly assumes that property tax increases involve no change in the structure of tax rates.

TABLE 4.5

The Distribution of Costs of Water Pollution Abatement in the Merrimack River Basin Assuming Full Financing by the Property Tax by Towns

Income Class	Burden as a Percent of Annual Income
Under $2,000	2.0 %
2,000- 4,000	1.7
4,000- 6,000	1.4
6,000- 8,000	1.3
8,000-10,000	1.2
10,000-15,000	1.1
15,000-20,000	1.0
20,000-30,000	.90
30,000-50,000	.87
50,000+	1.0

cost side, at least, water pollution abatement programs are clearly regressive.

Consider now the effects of supplementing property tax revenues with some form of expenditure substitution. Under the assumption of a conservative hypothetical budget, 64 percent of the expenditures in Nashua and Leominster are financed through property tax increases; the remaining 36 percent of water pollution abatement costs are financed through selective expenditure substitution. Under assumptions of a more liberal growth path, only an average of 39 percent of these new costs are covered by property tax increases; fully 60 percent are financed through expenditure cut backs in other areas. What effect does this have on the original cost distribution?

Two alternative incidence estimates are presented; one assuming conservative town budget growth, and a second assuming a more liberal growth rate. In generating the alternative incidence estimates, several additional assumptions were made:

1. The whole basin area will finance water pollution abatement via the average scheme historically used by Nashua and Leominster--viz. alternatively 64 percent and 39 percent financed through property tax increases.

2. The expenditure substitution is divided equally between expenditures on natural resources, a proxy for recreation and parks, and miscellaneous expenditures, a proxy for public safety.

These two assumptions, coupled with the expenditure incidence work discussed in the previous section, generate the distribution of water pollution abatement costs given in Table 4.6.

Several conclusions emerge from a comparison of Tables 4.5 and 4.6. First, given the types of expenditures which towns are most likely to reduce in response to water pollution abatement legislation, expenditure substitution results in greater regressivity of costs than does property tax financing. By and large, the distribution of foregone benefits of reduced expenditures is more regressive than is the property tax. Thus, previous studies which assumed pure tax financing of new water programs have, to some extent, underestimated the regressivity of these programs.

In terms of government policy, the conclusions generated here have further, more important, implications. In particular, it is clear that the distributional effects of new water pollution abatement programs are quite sensitive to the mechanism used to fund these programs. However, previous work suggested that the only real tool available for altering maldistributional consequences was to alter the percentage of the costs of these programs financed by local governments. My results suggest that this is not true. In particular, the distribution of costs of water pollution abatement programs may be altered significantly by local governments acting by themselves: they need only alter the mix of currently available funding sources. This is an important policy conclusion

TABLE 4.6

The Distribution of Costs of Water Pollution Abatement on the Merrimack, Assuming Financing Through Property Tax Increases and Selective Expenditure Substitution

Conservative Growth (64% Financed Through Property Tax)		Liberal Growth (39% Financed Through Property Tax)	
Income	Cost as a % of Income	Income	Cost as a % of Income
Under $2,000	3.4 %	Under $2,000	4.1 %
2,000 - 4,000	2.3 %	2,000 - 4,000	2.5 %
4,000 - 6,000	1.8 %	4,000 - 6,000	1.9 %
6,000 - 8,000	1.6 %	6,000 - 8,000	1.6 %
8,000 -10,000	1.4 %	8,000 -10,000	1.4 %
10,000 -15,000	1.3 %	10,000 -15,000	1.2 %
15,000 -20,000	1.2 %	15,000 -20,000	1.1 %
20,000 -50,000	.9 %	20,000 -50,000	.9 %
50,000 +	1.5 %	50,000 +	1.6 %

since it places at least some responsibility for the maldistributional results of federal policy back into the hands of local governments and suggests that cost distributions may be altered without further centralizing budgetary responsibility.

In Chapter 5, the second side of water pollution abatement expenditures is considered: the nature and distribution of the benefits of water pollution abatement programs.

5. The Distribution of Benefits of Water Pollution Abatement Among Income Classes

The net benefits which accrue to an individual from the consumption of x units of good y may be expressed as the difference between the amount that individual is willing to pay for that good and its actual cost. In more formal terms, if the marginal utility of income is assumed constant over the relevant range, net benefits are equal to the consumer's surplus triangle.

If the good under consideration is a private good, the derivation of this net benefit figure is relatively straightforward. Willingness to pay is equivalent to the area under the consumer demand curve; this demand curve is in turn estimateable from data on market transactions. In the case of public goods, however, estimating consumer benefits is somewhat more problematic. In particular, since the full benefits of the production of a public good are not appropriable through market transactions, meaningful demand curves are not in general revealed by market behavior. Thus, some alternative approach to demand or benefit measurement is necessary.

Several rather diverse techniques for estimating the benefits of water pollution abatement programs are used in this chapter. In Section 5.1, a fairly straightforward engineering approach is described and applied: here, benefits are estimated entirely from data on current and expected river quality coupled with data on the proximity of alternative recreational facilities to basin residents. In Section 5.2, several more conventional utility-based techniques for estimating benefits are described; and, finally, in Section 5.3, some empirical results generated by the application of these utility-oriented benefit estimation techniques to the Merrimack River Basin are reported. The estimates of the incidence of water pollution abatement benefits generated by this latter work are contrasted with the cost estimates of Chapter 4 to provide net incidence figures.

5.1 An Engineering Approach to Benefit Estimation

The objective benefits which will accrue to residents of the Merrimack River Basin from current water pollution efforts depend primarily on three factors:

(1) the current river quality;

(2) the expected future river quality given the current abatement efforts; and

(3) the quality and quantity of other water bodies in the area.

A comparison of items (1) and (2) above provides an estimate of the actual physical benefits which will be generated by pollution abatement efforts. Factor (3) is an index of the availability of substitutes for the polluted river; it thus affects the elasticity of demand for water pollution abatement on the particular river segment under study.

Previous work in the area of benefit estimation has concentrated, at least implicitly, on estimating people's indifference maps as between water quality improvements and income. Clearly, the three factors listed above represent arguments of those utility functions; typically, other economic, social, and demographic attributes of individuals enter as arguments of these utility functions as well. In fact, the empirical tests presented in Section 5.3 of this work represent an attempt to estimate these utility functions.

There are, however, some theoretical problems implicit in this approach. It should be clear that the broad welfare goal implicit in programs predicated on a utility-oriented benefit estimation technique is to maximize some sum of individuals' utilities. The appropriateness of using utilities as a basis for government policy in the area of water pollution abatement, however, is unclear.

In particular, to a large extent, tastes for clean water are endogenous; that is, an individual's demand for clean water depends at least partially on his previous experience with clean water. This endogeneity is largely a function of the phenomenon of learning-by-doing. Individuals in areas which have historically had clean rivers learn to exploit the advantages of that resource and, thus, value its benefits highly. Conversely, if a river has historically suffered from severe pollution, area residents may have never learned to enjoy the benefits associated with a clean river; thus, they may value pollution abatement efforts quite low.[1] The existence of significant learning-by-doing effects suggests that, in severely polluted river areas, benefit estimates based on pre-abatement willingness to pay surveys will be considerably lower than the benefits which in fact accrue to area residents from pollution abatement projects.

---

[1]Marc Roberts, et. al., Metropolitan Water Management, a study done for the National Water Commission by Urban Systems Research and Engineering, Inc., January, 1971.

Under these conditions, the appropriate measure of benefits, *ex post* or *ex ante*, is unclear. Moreover, the optimality of using individuals' utilities as the arguments of the social welfare function at all is no longer obvious. Much of the learning-by-doing effect involves simple habit formation; that is, *ex post* benefit valuation tends to be high because people become habituated to recreational water consumption. We have a situation analogous to the one in which we try to evaluate the benefits derived by individuals from a heavily advertised product: if a firm first creates a taste for a good and then satisfies it, it is not entirely clear, in a normative sense, how we should view that satisfaction. Philosophically or ethically, of course, some judgment can be made; in particular, to the extent that we view river appreciation as a "good", then the process of creating a taste for that good and then fulfilling it would seem to be a positive action. This position, of course, argues for the use of *ex post* benefit figures. However, within the context of strict positive economics, the right choice remains ambiguous.

It should be noted that the learning-by-doing effect in particular may result, not only in an underestimate of aggregate benefits, but in a misestimation of the distribution of benefits among income classes as well. The strength of the learning-by-doing effect, at least in the area of water recreation opportunities, seems to be inversely related to income levels. High income people can travel to "learn" the value of clean water; learning opportunities for lower income people are more restricted. Furthermore, better educated people tend to be more adept at making abstractions; thus, immediate experience is somewhat less critical in their valuation processes. Thus, to the extent that education and income are collinear, this factor too suggests a systematic difference among income classes in the deviation of expected and actual benefits from water pollution abatement programs.

A similar systematic discrepancy between expected and actual benefits from water pollution abatement programs is produced by land use changes. One would expect a program of river quality improvement to be followed by some change in the use of land surrounding the river; in particular, we would expect a new land use configuration to emerge which would exploit the new river quality. Ex ante benefit surveys implicitly assume pre-clean-up land use patterns; thus, for this reason as well, these surveys are likely to understate actual benefits.

In short, in circumstances in which government policy, in the process of fulfilling demand, in fact systematically alters that demand, the use of preferences as a policy guide may no longer be appropriate.

Given this ambiguity, in this study, two different estimates of the benefits of water pollution abatement are given.

In Section 5.3, the results of an ex ante utility-oriented survey approach are presented. In generating benefit estimates from the survey data, the problem of endogeneity of tastes is largely ignored.[2]

In the remainder of this section, an alternative benefit estimation technique is applied. This technique takes account of the endogeneity of tastes; it provides, however, only a first, rough approximation of benefits. Rather than attempting to measure utilities, I directly measure the three main arguments of the utility function described above--current river quality, expected future river quality given the abatement program, and availability of alternative facilities--and try to infer ex post benefit levels from these variables.

The major differences between this type of benefit estimation and the willingness to pay estimates generated later in this study should be clear. In the latter studies, the implicit social welfare objective is to maximize some sum of utilities; our principal concern then is the distribution of these utilities across income groups. In the technique applied here, concern is with the distribution of actual physical results; the implicit social welfare objective is to

---

[2]While the Section 5.3 estimates are generated without reference to the issue of endogeneity of tastes, the survey data itself allows us to make some inferences about the strength of the learning-by-doing effect and, thus, suggests appropriate adjustments.

equalize access to opportunities across individuals. Once again, it is fairly clear that, if water pollution abatement were a private good, the appropriate benefit measure would be the one based on utilities; however, since water pollution abatement is a public good, and since tastes for it are to some extent endogenous, the objective of equal access may in fact be more appropriate. At any rate, both estimates are given in this study.

The procedure followed here is quite straightforward. The analysis is restricted to recreational benefits: these are the benefits most likely to be affected by pollution abatement programs. We further restrict the analysis to those benefits which accrue to residents of the Merrimack River Basin.

First, the actual river quality improvement (Factors 1 and 2) expected by each town in the study area from new expenditures is estimated. These physical quality changes are then transformed into changes in the recreational opportunities available in the river. Current river quality and recreational opportunities estimates were provided by the Environmental Protection Agency; expected future quality and opportunities were estimated from Army Corps information. There is clearly some uncertainty involved in mapping between pollution abatement expenditures and river quality improvements; for this study, however, this uncertainty is ignored.

The second step in this analysis is to place some value on the incremental opportunities afforded by the pollution abatement expenditures. This valuation is accomplished by looking at the third argument of the recreationist's utility function--the availability of substitutes. That is, we measure the median distance town residents must currently travel to enjoy these incremental opportunities and assume that the value of these new benefits is directly related to the distance an individual is from an alternative equivalent site. The value, then, of each incremental opportunity provided by the pollution abatement program is expressed in miles saved. Notice, I am not using the distance people actually travel for recreation as a proxy for benefits; this is a well-known utility-oriented technique and will be discussed in the next section. I am considering, instead, the minimum distance people must travel in order to enjoy particular recreational experiences. This valuation technique reflects the underlying social welfare function--viz. equalizing access, not utilities.

No attempt has been made to transform these estimates of distance saved into dollars. Considerable work has been done in the past, particularly in the area of transportation economics, on estimating the value of distance of time saved;[3]

[3] See, for example, John Meyer and Mahlon Straszheim, Pricing and Project Evaluation, Vol. 1 (Washington, D.C., Brookings, 1971).

the results of this work are conflicting and, in general, unconvincing.

The by-town aggregate benefit estimates generated by this method are presented in Table 5.1. In Table 5.2, the relationship between these benefits and the median income of the study towns is presented; since all town residents are assumed to be equidistant from alternative facilities, it is not possible to construct a within-town distribution of benefits by income class. The town benefits from water pollution abatement are next compared to the per capita expenditures made by that town. Thus, an estimate of the distribution among towns in the study area of the net physical benefits of the new pollution abatement program is provided.

The relationship between town median income and the net expected benefits from water pollution abatement programs has been graphed in Figure 5.1.

The pattern which emerges from this analysis is somewhat random, although net benefits do seem to increase somewhat with income. Thus, there is some indication that higher income towns differentially benefit from water pollution abatement programs.

In Sections 5.2 and 5.3, an alternative technique for estimating benefit incidence is outlined, and alternative benefit incidence estimates are presented.

TABLE 5.1

By-Town Benefits of Water Pollution Abatement Programs

TOWN	CURRENT RECREATIONAL OPPORTUNITIES	FUTURE RECREATIONAL OPPORTUNITIES	INCREMENTAL RECREATIONAL OPPORTUNITIES	DISTANCE TO NEAREST ALTERNATIVE			VALUE IN MILES			TOTAL VALUE IN MILES
				B	F	S	B	F	S	
Alton	B,F,S	B,F,S	0	0	0	0	--	--	--	0
Andover	0	B,F,S	B,F,S	20	20	20	20	20	20	60
Bedford	B,F	B,F	0	--	--	--	--	--	--	0
Belmont	B,F	B,F,S	S	--	--	8	--	--	8	8
Billerica	0	B,F	B,F	10	10	--	10	10	--	20
Bow	B,F	B,F,S	S	--	--	6	--	--	6	6
Boscawen	B,F	B,F,S	S	--	--	12	--	--	12	12
Chelmsford	0	B,F,S	B,F,S	10	10	26	10	10	26	46
Concord	B,F	B,F,S	S	--	--	20	--	--	20	20
Dracut	0	B,F	B,F	20	20	0	20	20	0	40
Fitchburg	0	B,F	B,F	10	10	--	10	10	--	20
Franklin	B,F	B,F,S	S	--	--	15	--	--	15	15
Gilford	B,F,S	B,F,S	-----	0	0	0	0	0	0	0
Goffstown	B,F	B,F,S	S	0	0	10	0	0	10	10

TABLE 5.1 (continued)

TOWN	CURRENT RECREATIONAL OPPORTUNITIES	FUTURE RECREATIONAL OPPORTUNITIES	INCREMENTAL RECREATIONAL OPPORTUNITIES	DISTANCE TO NEAREST ALTERNATIVE			VALUE IN MILES			TOTAL VALUE IN MILES
				B	F	S	B	F	S	
Gorham	0	B,F	B,F	22	24	--	22	22	--	44
Groveland	0	B,F	B,F	8	8	0	8	8	0	16
Haverhill	0	B,F	B,F	8	8	0	8	8	0	16
Henniker	B,F,S	B,F,S	0	--	--	--	--	--	--	0
Hillsborough	B,F,S	B,F,S	0	--	--	--	--	--	--	0
Hooksett	B,F	B,F,S	S	--	--	12	--	--	12	12
Hopkinton	B,F,S	B,F,S	0	--	--	--	--	--	--	0
Hudson	0	B,F	B,F	6	6	--	6	6	--	12
Jaffrey	B,F	B,F,S	S	--	--	16	--	--	16	16
Laconia	B,F	B,F,S	S	0	0	2	0	0	2	2
Lancaster	0	B,F	B,F	7	7	--	7	7	--	14
Lawrence	0	B,F	B,F	9	9	--	9	9	--	18
Leominster	0	B,F	B,F	5	5	--	5	5	--	10
Lowell	0	B,F	B,F	15	15	--	15	15	--	30

TABLE 5.1 (continued)

TOWN	CURRENT RECREATIONAL OPPORTUNITIES	FUTURE RECREATIONAL OPPORTUNITIES	INCREMENTAL RECREATIONAL OPPORTUNITIES	DISTANCE TO NEAREST ALTERNATIVES			VALUE IN MILES			TOTAL VALUE IN MILES
				B	F	S	B	F	S	
Lunenberg	0	B,F	B,F	10	10	--	10	10	--	20
Manchester	B,F	B,F	0	--	--	--	--	--	--	0
Meredith	B,F,S	B,F,S	0	0	0	0	0	0	0	0
Merrimack	B,F	B,F,S	S	--	--	10	--	--	10	10
Methuen	0	B,F	B,F	14	14	--	14	14	--	28
Milford	B,F	B,F,S	S	--	--	16	--	--	16	16
Nashua	0	B,F	B,F	11	11	--	11	11	--	22
New London	B,F	B,F,S	S	--	--	20	--	--	20	20
North Andover	B,F	B,F,S	S	--	--	15	--	--	15	15
Northfield	B,F	B,F,S	S	--	--	15	--	--	15	15
Pembroke	B,F	B,F,S	S	--	--	15	--	--	15	15
Peterborough	B,F,S	B,F,S	0	--	--	--	--	--	--	0
Pittsfield	B,F	B,F,S	S	--	--	12	--	--	12	12
Plymouth	B,F,S	B,F,S	0	--	--	--	--	--	--	0

TABLE 5.1 (continued)

TOWN	CURRENT RECREATIONAL OPPORTUNITIES	FUTIRE RECREATIONAL OPPORTUNITIES	INCREMENTAL RECREATIONAL OPPORTUNITIES	DISTANCE TO NEAREST ALTERNATIVE			VALUE IN MILES			TOTAL VALUE IN MILES
				B	F	S	B	F	S	
Sanbornton	B,F	B,F,S	S	--	--	6	--	--	6	6
Tewksbury	0	B,F	B,F	20	20	--	20	20	--	40
Tilton	B,F	B,F,S	S	--	--	10	--	--	10	10
Warner	B,F	B,F,S	S	--	--	15	--	--	15	15
Westminster	0	B,F,S	0	5	5	--	5	5	--	10
Wolfeboro	B,F,S	B,F,S	0	0	0	0	0	0	0	0

TABLE 5.2

Net Benefits and Town Income

TOWN	MEDIAN INCOME	BENEFITS	PER CAPITA EXPENDITURES	EXPENDITURES÷BENEFITS (miles saved per $)
Alton	$ 7000	0	379.47	0
Andover	12730	60	27.00	2.22
Bedford	11677	0	17.78	0
Belmont	7000	8	45.23	.18
Billerica	10928	20	8.79	2.28
Bow	7500	6	51.30	.12
Boscawen	6569	12	84.76	.14
Chelmsford	13092	46	30.16	1.52
Concord	7589	20	51.22	.39
Dracut	10282	40	30.33	1.32
Fitchburg	7676	20	148.58	.13
Franklin	7523	15	45.25	.33
Gilford	10720	0	45.26	0
Goffstown	6626	10	29.72	.34
Gorham	8000	44	45.23	.97
Groveland	11052	16	59.45	.27
Haverhill	7631	16	62.44	.26
Henniker	7000	0	57.58	0
Hillsborough	7242	0	135.13	0

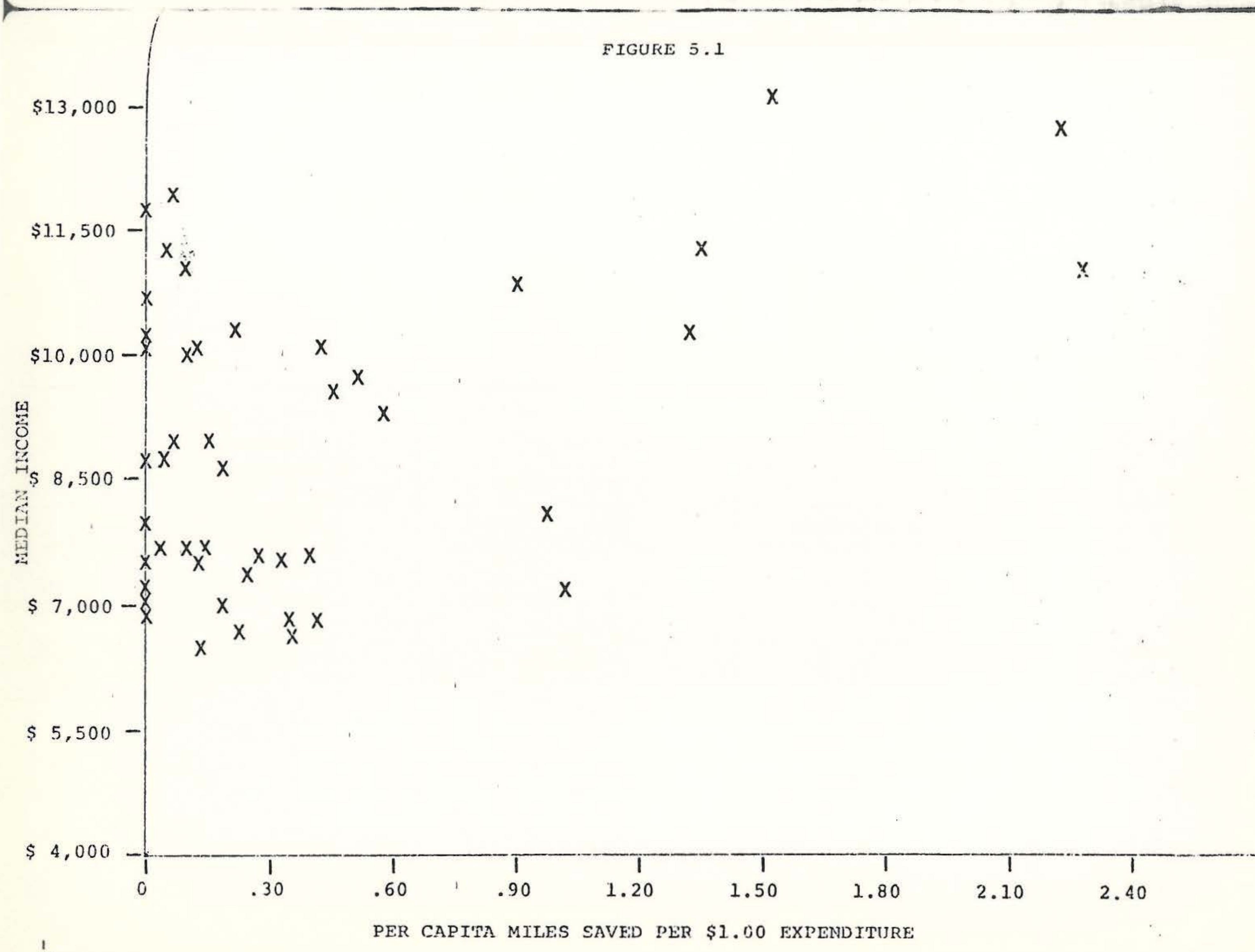
TABLE 5.2 (continued)

TOWN	MEDIAN INCOME	BENEFITS	PER CAPITA EXPENDITURES	EXPENDITURES÷BENEFITS (miles saved per $)
Hooksett	$ 8683	12	69.89	.17
Hopkinton	10802	0	126.37	0
Hudson	10956	12	13.53	.89
Jaffrey		16		
Laconia	7696	2	183.29	.01
Lancaster	9500	14	31.23	.45
Lawrence	7367	18	71.25	.25
Leominster	8985	10	68.25	.15
Lowell	7376	30	29.90	1.00
Lunenberg	10316	20	171.72	.12
Manchester	7500	0	17.49	0
Meredith	8022	0	98.08	0
Merrimack	11384	10	281.95	.04
Methuen	9739	28	55.50	.50
Milford	6888	16	42.85	.37
Nashua	9302	22	37.63	.58
New London	12000	20	241.50	.08
North Andover	10249	15	38.32	.39
Northfield	6800	15	45.22	.33
Pembroke	8923	15	255.80	.06

TABLE 5.2 (continued)

TOWN	MEDIAN INCOME	BENEFITS	PER CAPITA EXPENDITURES	EXPENDITURES÷BENEFITS (miles saved per $)
Peterborough	$10719	0	249.69	0
Pittsfield	8707	12	333.73	.04
Plymouth	4470	0	17.75	0
Sanbornton	8000	6	45.20	.13
Tewksbury	11250	40	29.95	1.34
Tilton	6843	10	45.26	.22
Warner	10000	15	159.61	.09
Westminster	10350	10	49.61	.20
Wolfeboro	8791	0	57.64	0

FIGURE 5.1


$13,000
$11,500
$10,000
$ 8,500
$ 7,000
$ 5,500
$ 4,000
MEDIAN INCOME
0
.30
.60
.90
1.20
1.50
1.80
2.10
2.40
PER CAPITA MILES SAVED PER $1.00 EXPENDITURE

5.2 Estimating Demand Curves

There have been a number of attempts to circumvent the problem of lack of market data and to estimate the demand for water quality improvements. Early Army Corps of Engineers' studies used a gross cost method: benefits were assumed to be equal to the costs of providing the given quality improvement. The use of this particular technique is clearly specious; in addition to justifying all projects, it does not differentiate among projects. A similarly unfruitful method which has been used in the past is to value benefits at the market price of additional fish caught as the river quality improves: clearly this technique limits itself to one small class of benefits.[4] Two other methods for estimating the demand for water quality improvements are somewhat more viable: the travel cost method and the survey method. In this section, the theoretical framework, procedures, and results generated by each of these methods are reviewed.

5.2.1 The Travel Cost Method

If we begin with a simple model of a single river site, it is clear that the recreational demand for that site will be given by:

---

[4]For a discussion of the use of these two techniques--gross cost and value of fish, see Jack Knetsch and Robert Davis, "Comparisons of Methods for Recreation Evaluation", in Knesse and Smith, Water Research (Baltimore, Maryland, Johns Hopkins Press, 1965).

(1) $V = V(Y, P, R)$

where V = number of visits; the quantity measure
Y = set of individual attributes
R = set of facility attributes
P = price of a user-day

In estimating a demand curve, we are concerned with the relationship between V and P. The price of environmental quality, however, is not available and, instead, must be inferred from other data. The usual technique is to use travel costs plus entrance fee as a proxy for the price. We can then, by looking at the relationship between travel costs and number of visits at an existing site, and by controlling for Y and R, predict the number of visits of demand for a new site.

The use of the travel cost method originated with Hotelling.[5] The Hotelling model, however, is somewhat simpler than the model given in (1) above. Hotelling looks simply at:

(2) $V = V(P, R)$

That is, he assumes that all visitors to a particular site value it equally. The household driving the greatest distance is considered the marginal unit; consumers' surplus is estimated as the difference between the distance travelled by the marginal unit and the distance travelled by all the intramarginal households.

---

[5]H. Hotelling, in Roy A. Prewitt, The Economics of Public Recreation, U. S. Department of the Interior, National Park Service, 1949.

Clawson later relaxed this assumption of strict homogeneity of individuals to some extent.[6] Clawson initially aggregated households into zones of origin, where zones are defined by distance from the site. He then considered the relationship between visits per capita per zone and distance of the zone from the study area. Thus, Clawson assumes only homogeneity of zones, and not homogeneity of individuals across zones. Clearly, in order for this approach to be valid, the zones must be defined in such a way that it is meaningful to assign a unique travel cost to each zone, and further to assume that all zones are homogeneous with respect to their tastes for recreation.

A final extension of the travel cost method of estimating recreational demand is provided by Knetsch.[7] Unlike Hotelling and Clawson, Knetsch does not assume homogeneity either among individuals or across zones. Instead he directly estimates an equation in the form of Equation (1) above; as an index of site attributes or quality, Knetsch uses crowding and the availability of substitute facilities; as an index of individual tastes, he uses median income. Both variables are statistically important.

---

[6] Marion Clawson, Methods of Measuring the Demand for and Value of Outdoor Recreation, Reprint No. 10 (Washington, D. C., Resources for the Future, 1959).

[7] Jack Knetsch, "Outdoor Recreation Demands and Benefits", in Land Economics, Vol. 39, No. 4 (1963), pp. 387-397.

Even under the Knetsch formulation, the travel cost method retains a number of problems. In particular, it accounts only for recreational benefits which result from river quality improvement; clearly, there are additional benefits in terms of land value increases, option demand, and aesthetics which are being left uncounted. Moreover, there are problems in the use of this technique even in the area of narrow recreational benefits. In order to use estimates generated by use at an existing site to predict future use at a second site, we must assume complete comparability between sites. Knetsch attempts to deal with this by including crowding in his regression; it is clear, however, that this is a quite imperfect proxy for facility quality. Insuring complete comparability between sites would be quite difficult. A second problem is posed by the use of monetary costs of travel as the price index. The true costs of travelling include not only out-of-pocket expense, but the costs of time spent and the implicit utility/disutility of travelling. Omitting time from the price of recreational use clearly biases the demand curve to the left of the true curve;[8] the direction of the bias imposed by excluding the utility of travelling itself clearly depends on whether or not this process is pleasureable. Thus, while it is clear that restricting our attention to out-of-pocket costs biases our demand

---

[8]Knetsch, ibid.

estimate, the net direction of that bias is unclear.

Despite the problems implicit in the travel cost method, it does provide a reasonably objective method of estimating demand. In Section 5.3, some use will be made of the travel cost model in estimating demand; in particular, we will be concerned with current travel costs incurred by individual recreationists and their respective willingnesses-to-pay for river quality improvements. The willingness-to-pay technique is discussed further below.

5.2.2 Survey Techniques

As an alternative to the travel cost method, several studies have estimated demand curves for water quality improvement by interviewing people and asking them to define their own preferences. Two variants of this technique have been used: user-day analysis and direct willingness-to-pay.

A first approximation of the benefits which will accrue from water pollution abatement programs can be obtained by estimating the frequency with which "clean" rivers will be used for recreational activity. Typically, surveys collect information on the social and economic attributes of individuals and, simultaneously, on the number of days these individuals expect to use the cleaned-up river for particular activities (viz. swimming, fishing, and boating). By regressing user-days on variables such as income, sex, education, residence, and so on, we can estimate the distribution of the real, physical benefits of water pollution abatement. Furthermore, by looking at the coefficients generated by the user-day regression and the actual socio-economic attributes of area residents, we can estimate the aggregate user-day benefits of water pollution abatement.

One of the better applications of the user-day technique described above was a study by Davidson, Adams, and Seneca.[9] The data base used in this study was a 1959 University of Michigan Survey Research Center survey of the recreational use patterns of 1,352 households; data was collected on individual attributes, attributes of neighborhoods in which respondents live, and, finally, the frequency with which respondents engage in fishing, swimming, or boating. Davidson, Adams, and Seneca then estimated the functional relationship between recreational user-days and these individual and neighborhood attributes. As one might expect, user-days vary directly with income, education, and proximity to facilities. Davidson, Adams, and Seneca then applied the coefficients estimated from the University of Michigan survey to estimate the social value of water recreational facilities in the Delaware Estuary.

---

[9] Paul Davidson, F. Gerard Adams, and Joseph Seneca, "The Social Value of Water Recreational Facilities Resulting from an Improvement in Water Quality: The Delaware Estuary", in Knesse and Smith, Water Research (Baltimore, Maryland, Johns Hopkins Press, 1965).

The analysis described above yields an aggregate value and a distribution of values of water pollution abatement only in terms of user days; note that this technique does not generate dollar values for benefits which might then be compared with the dollar costs of the program proposed. Thus, this analysis does not indicate whether or not a particular program of water pollution abatement is efficient; moreover, unless some additional assumptions about the variation of user-day values with income are made, no information is generated about the progressivity or regressivity of water pollution abatement programs.

There have been several attempts to transform user-day estimates into dollar values. Davidson, Adams, and Seneca chose an arbitrary figure in order to make this transformation. In this analysis, the value of a user-day was chosen independently of the attributes of individuals; thus, the distribution of dollar benefits from pollution abatement follows directly from the distribution of physical benefits.

The Davidson, Adams, and Seneca approach of using a single value for a user-day may well be inappropriate. In particular, a decision-maker typically considers factors other than efficiency in choosing among alternative public programs; one way to incorporate these other goals into the decision process is by assigning different relative weights to user-days depending on specified attributes of individual users.

Thus, Mack and Meyer[10] suggest that water pollution abatement programs be judged by comparing their costs with merit-weighted user-days; merit weights are assigned here according to factors such as income of beneficiaries, area of the country, conservation-ecological disaster, and so on.

Even if one chooses to consider only strict economic efficiency, the use of a single value for a user-day may be inappropriate. Work in other fields, and, in particular, in transportation economics suggests that the value of time varies inversely with income.[11] Thus, one would expect individuals with different initial incomes to assign different dollar values to incremental recreational opportunities provided by water pollution abatement.

In addition to the problems discussed above in assigning meaningful dollar values to user-days, this technique has a second problem. In particular, it accounts only for recreational benefits and, thus, ignores potentially important benefits such as option demand, aesthetic improvements, and so on.

An alternative survey technique involves asking people what they would be willing to pay for given levels of water

---

[10] Ruth Mack and Sumner Meyers, "Outdoor Recreation", in Robert Dorfman, ed., Measuring the Benefits of Government Investment (Washington, D.C., Brookings, 1965), pp. 91-100.

[11] Anthony Blackburn, "A Non-linear Model of the Demand for Travel", in Richard Quandt, The Demand for Travel (Massachusetts, Heath Lexington Books, 1970), pp. 163-180.

quality improvement. Of the methods available for estimating the demand for environmental quality, this is the most theoretically promising. It should be noted, however, that, while this technique avoids problems of transforming days into dollars and provides an estimate of all classes of benefits, it nevertheless retains the problems imposed by endogeneity of tastes discussed in Section 5.1.

Perhaps the best application of the willingness-to-pay technique is the work done on the benefits of outdoor recreation sites in Maine by Knetsch and Davis.[12] In this study, Knetsch and Davis interviewed 185 hunters, fishermen, and campers, and collected information on their willingness to pay for site use, as well as on their social and economic characteristics. The willingness-to-pay information was gathered through a "bidding game", in which the researchers successively increased prices offered until respondents ended the game. As expected, both income and education were positively related to willingness to pay.

In the next section, I present the results of a willingness-to-pay survey, similar to the one described above, which I conducted in the Merimack River Basin. I further present the results of applying a user-day approach on the same survey population.

---

[12] Jack Knetsch and Robert Davis, "Comparison of Methods for Recreation Evaluation", in Knesse and Smith, Water Research (Baltimore, Md., Johns Hopkins Press, 1965).

5.3 Results of a Willingness-to-Pay Survey on the Merrimack River Basin

5.3.1 Survey Description

In order to elicit information on the potential benefits which might be expected to accrue from current water pollution abatement efforts on the Merrimack River, a willingness-to-pay survey was conducted. The responses to this survey provide an approximation of the expected utility of basin residents from current water pollution abatement expenditures. Surveys were administered by telephone.

A copy of the survey instrument is presented in Exhibit 1 below. Several characteristics of the questionnaire deserve mention.

First, in administering the questionnaire, the willingness-to-pay question was preceded by questions on frequency of use and availability of substitutes. Early survey testing suggested that people in general have considerable difficulty in assigning monetary values to clean water: typically, people considered clean rivers either priceless or worthless. Reordering questions so that river use characteristics and alternative opportunities for recreation preceded willingness-to-pay questions encouraged respondents to systematize their answers a little bit further.[13] It should be noted that,

---

[13]The observation that ordering matters has been made previously by political scientists, as well as by other researchers; in particular, the design of an agenda in voting situations can sometimes alter the results of votes. One of the earliest attempts to build a waste treatment plant in the

EXHIBIT 1

Questionnaire Used for the Willingness-to-Pay Survey on the Merrimack

To be completed by the interviewer:

1. Name of Respondent
2. Address
3. Sex

To be asked the respondent:

I am conducting a survey through Harvard University for the Environmental Protection Agency on public reaction to water pollution. I wonder if you would answer a few short questions for us?

1. As you probably know, there have been some efforts recently to clean up the _________ River. If the River were to be cleaned up, how many days per year would you use the River for the following activities:

   A. Boating

   B. Fishing

   C. Swimming

2. How far do you currently travel to fish, boat, and swim?

3. How much would you be willing to pay, either in the form of a tax increase or out-of-pocket per year to clean up the river so that the above activities would be possible?

Now we have several questions which the E.P.A. wants to use to put your answer in a statistical context.

1. How many people are currently living with you in your family?

2. Do you rent or own your home?

3. What is the highest grade of education you have completed?

4. Is your average family yearly income in the range:

   Less than $3,000
   3,000-5,000
   5,000-10,000
   10,000-15,000
   15,000-20,000
   20,000-25,000
   25,000+

Thank you very much.

despite this re-ordering, some reluctance to value clean water in monetary terms remained; survey results should therefore be treated cautiously.

Interview responses are sensitive, not only to the ordering of questions, but to the structure of the willingness-to-pay question as well. Concretizing the question, by tying willingness to pay to willingness to incur either tax increases or user charges, increases the incentives for respondents to understate their preferences; respondents more often suspected the interviewers of being either environmental groups in search of donations or city officials in search of additional revenue. On the other hand, abstract demand questions are much more difficult for people to answer and may well be a less realistic assessment of true willingness to pay. The survey question used here attempted to strike a balance between these two problems; multiple disclaimers of association with either fund-raising groups or government were made.

In order to insure some consistency in the way in which questions were asked, all interviews were conducted by either myself or my husband.

Merrimack Basin was defeated largely because it was embedded in the town referendum between three anti-labor issues and three anti-Church questions. (I owe this story to Jack McKee, of Camp, Dresser, and McKee, an engineering firm responsible for much of the waste treatment facility construction in the Merrimack Region.)

The survey yielded 200 useable responses, out of total attempted questionnaires of 400. The benefit figures generated by the survey are, in all likelihood, biased upward to some extent: typically, environmentally conscious people were differentially willing to answer survey questions.

The 200 interviews were divided among towns by first assigning one interview to each of the fifty towns, and then dividing the remaining 150 interviews according to the relative populations of each of the towns. Particular respondents from each town were then chosen randomly from telephone directories. The characteristics of the sample generated by this method are given in Tables 5.3 and 5.4 below. It should be noted that, despite the relatively simplistic sample selection design, the sample attributes which resulted correspond closely to the characteristics of the underlying basin population.

5.3.2 Survey Results on the Distribution of Benefits of Water Pollution Abatement Programs on the Merrimack River

The data generated by the survey described in Section 5.3.1 was used to address two major questions:

(1) What is the aggregate willingness to pay or demand for water pollution abatement in the Merrimack River Basin?

(2) What are the determinants of this demand for water pollution abatement?

The answer to Question 1 can be compared with total costs of water pollution abatement provided in Chapter 4 to give an

TABLE 5.3

Interviews by Town in the Sample

TOWN	NO. OF INTERVIEWS	TOWN	NO. OF INTERVIEWS
Massachusetts		New Hampshire	
Andover	5	Alton	2
Billerica	7	Bedford	2
Chelmsford	8	Belmont	1
Dracut	4	Bow	2
Fitchburg	8	Boscawen	2
Groveland	2	Claremont	4
Haverhill	10	Concord	7
Lawrence	13	Franklin	2
Leominster	7	Gilford	2
Lowell	19	Goffstown	2
Lunenberg	2	Gorham	2
Methuen	7	Henniker	2
North Andover	4	Hillsborough	2
Tewksbury	5	Hooksett	2
Westminster	2	Hopkinton	2
		Hudson	2
		Jaffrey	2
	103	Laconia	4
		Manchester	17
		Meredith	2
		Merrimack	2
		Milford	2
		Nashua	11
		New London	2
		Northfield	2
		Pembroke	2
		Peterborough	2
		Pittsfield	2
		Plymouth	2
		Sanbornton	2
		Tilton	2
		Warner	1
		Wolfeboro	2
			97

TABLE 5.4

Sample Characteristics

Attribute	Number of Respondents
All	200
Income Level	
Less than 3,000	10
3 - 4,999	16
5 - 9,999	50
10 - 14,999	66
15 - 19,999	34
20 - 24,999	12
25,000 +	12
Education	
Less than High School	34
High School	83
1-2 Years College	42
2.1-3.9 Years College	3
4 Years College	26
Masters	8
Ph.D.	4
Sex	
Male	91
Female	109
Home Ownership	
Rent	46
Own	154
Family Size	
1	11
2	51
3	36
4	37
5	32
6	17
7	10
8	3
9	2
10	0
11	1

estimate of the overall efficiency of current programs. Question 2 is relevant to the issue of incidence or equity of water pollution abatement programs.

The primary interest in this study is the extent to which the benefits of water pollution abatement will accrue to individuals in different income classes. The principal data relevant to this issue is contained in Tables 5.5 and 5.6: cross tabulations of, first, income and willingness to pay for clean-up of the Merrimack, and, second, of income and the frequency with which individuals expect to use a cleaned-up river for recreation. These two tables are discussed in more depth below.

The median amount individuals in all income classes are willing to pay for water pollution abatement on the Merrimack is $12.14. This willingness-to-pay figure, however, varies considerably by income. Seventy-three percent of the individuals with family incomes less than $5,000 were willing to pay only between $0 and $5 per year for water pollution abatement programs; only 20 percent of the respondents with incomes over $15,000 had demand prices less than $5. Similarly, only 11 percent of the individuals with incomes less than $5,000 were willing to pay as much as $100 for pollution abatement; 22 percent of the individuals with incomes over $15,000 fell into this category. This positive relationship between income and willingness to pay for water pollution abatement

TABLE 5.5

Cross Tabulation of Income

and Willingness to Pay

Willingness to Pay

Income	$0-5	6-10	11-25	26-49	50-99	100-199	200+	TOTAL
Less than $3,000	9	0	0	0	0	1	0	10
3,001 - 4,999	10	1	3	0	0	1	1	16
5,000 - 9,999	20	6	5	1	8	7	3	50
10,000 - 14,999	21	8	15	2	6	9	5	66
15,000 - 19,999	7	6	4	0	8	7	2	34
20,000 - 24,999	2	2	6	0	2	0	0	12
25,000 +	3	0	2	2	1	2	2	12
TOTAL	72	23	35	5	25	27	13	200

TABLE 5.6

Cross Tabulation of Frequency of Use and Income

Frequency of Use Income	0-5 days	6-10	11-25	26-49	50-99	100-199	200+	TOTAL
Less than $3,000	8	0	0	0	0	1	1	10
3,000 - 4,999	7	1	1	2	1	1	3	16
5,000 - 9,999	16	2	5	5	13	6	3	50
10,000 - 14,999	16	2	11	12	14	8	3	66
15,000 - 19,999	8	3	8	3	5	6	1	34
20,000 - 24,999	4	2	2	0	4	0	0	12
25,000 +	4	3	1	1	0	1	2	12
TOTAL	63	13	28	23	37	23	13	200

efforts on the Merrimack was significant at the .01 level. The elasticity of willingness to pay with income evaluated in the intervals \$5,000-\$10,000 to \$15,000-\$20,000 is 1.2. This income elasticity was derived by assuming all income recipients in a class are to be found at the midpoint of that class.

As I indicated earlier, people have a great deal of difficulty in assigning a dollar value to river quality. Thus, the income elasticity cited above should be treated with some caution. There are two techniques which can be used to circumvent the problems implicit in directly asking people about their willingness to pay. First, we can ask people about expected use of the river; we can then either look directly at the variation of these user days by income or transform user days into dollars to provide an estimate of the distribution of dollar benefits by income class. This user-day approach has clear advantages in terms of providing more reliable responses than willingness-to-pay questions. Furthermore, there is some question as to whether the high income elasticity generated by willingness-to-pay estimates is attributable to diminishing marginal utility of income at higher income levels or to a difference in the propensity of people at different income levels to use recreational facilities. A user day-income cross tabulation can help sort out these two influences.

In Table 5.6, the user day-income relationship is summarized. The median number of days respondents expect to use the Merrimack, given a clean-up effort, for any recreational activity is 12.85 days. A primitive comparison of this figure with the median willingness-to-pay figure suggests that people value the provision of an extra recreational day at about $1. Frequency of use, however, also varies with income. Fifty-eight percent of the respondents with family incomes less than $5,000 expected to use the river only five days or less. Only 28 percent of those interviewed with incomes over $15,000 fell into this low use category. The relationship between frequency of use and income, however, seems to be S-shaped. That is, low income people are clustered at either end of the use classes; they seem to be either very light users of recreation or fairly heavy users. This S-shape may reflect the fact that low income people are typically either old, and thus light users, or students, and therefore potentially heavy users. The relationship between frequency of use and income is also significant at the .01 level. However, the elasticity of use with respect to income is, unlike the elasticity of willingness to pay, quite low. If we evaluate elasticity between the intervals of $3,000-$5,000 and $15,000-$20,000, we find an income elasticity of only .42.

The lower income elasticity generated by the user-day approach suggests that the primary reason lower income people place a lower value on river clean-up than do high income people is because of the different values these two groups place on money, and not because of differences in the real, physical benefits which they expect to receive from water pollution abatement. This conclusion, however, must be treated with some caution. In particular, user-day estimates reflect only recreational demand for river quality improvements. Aesthetic demand and option demand are not captured in the user-day approach. Willingness-to-pay estimates capture all benefits of river quality improvements. Since both aesthetic demand and option demand tend to be luxury goods, income elasticity figures based on the user-day approach will invariably be less than elasticities derived from a willingness-to-pay survey. In summary, the differential between user-day and willingness-to-pay income elasticities is attributable both to the diminishing marginal utility of money and to the differences in benefit definitions implicit in the two approaches.

The user-day approach to benefit estimation, while more reliable than willingness-to-pay questions, still requires respondents to make estimates of their future behavior; thus, estimation problems still exist which might confound the results. An alternative approach is to <u>infer</u> willingness to pay, or demand for clean water, from data collected on the distance people currently travel to recreate. This revealed preference oriented technique is a variant of the Hotelling-Clawson travel cost method described in Section 5.2.1. Clearly, the use of miles currently travelled as a proxy for demand for river quality is imperfect. In particular, it provides only a lower bound for recreational benefits which might accrue to basin residents from a clean-up of the Merrimack. Nevertheless, since estimates of miles travelled require little "guess-work" on the part of respondents, it is probably somewhat more reliable than either the willingness-to-pay or the user-day estimate.

In Table 5.7, I present a cross tabulation of income and miles currently travelled by respondents to recreational facilities. The median distance Merrimack Basin residents currently travel to recreate is 10.3 miles. Once again, if we make a primitive comparison of the willingness-to-pay estimates given earlier and distance travelled, it appears that Basin residents value a mile of distance saved at about $1.17. The data reveals a positive relationship between income and miles travelled for recreation. Thus, 69 percent of the respondents with family incomes less than $5,000 currently travel less than 5 miles for recreation--most do not recreate at all or are less sensitive to river quality in their choice of recreational facilities; only 34 percent of those interviewed with incomes greater than $15,000 travelled less than 5 miles for recreation. The positive relationship between income and miles travelled is significant at the .05 level. The elasticity

TABLE 5.7

Cross Tabulation of Miles Travelled and Income

Miles Travelled to Recreate Income	0-5 miles	6-10	11-25	26-49	50-99	100+	TOTAL
Less than 3,000	10	0	0	0	0	0	10
3,000 - 4,999	8	1	5	1	0	1	16
5,000 - 9,999	15	6	13	8	5	3	50
10,000 - 14,999	28	6	16	11	5	0	56
15,000 - 19,999	11	2	7	8	4	2	34
20,000 - 24,999	4	1	1	1	2	3	12
25,000 +	5	2	2	0	3	0	12
TOTAL	81	18	44	29	19	9	200

of miles with respect to income is quite low; evaluated in the range between $5,000-$10,000 and $15,000-$20,000, it is only .21. Once again, this low elasticity at least in part reflects the narrow definition of river quality improvement benefits implicit in the travel cost approach.

In summary, the data collected in this survey suggests that the benefits of water pollution abatement programs increase with income. The high income elasticity of demand generated by the willingness-to-pay analysis further suggests that river quality is a luxury good---i.e. demand for water pollution abatement increases more than proportionately with income. This result, coupled with the information on cost incidents discussed in Chapter 4, suggests that new water pollution abatement expenditures are likely to be regressive; that is, poor people reap smaller net benefits than do higher income people. This result is discussed more formally in Section 5.4.

In addition to income, I also considered the relationship between willingness to pay and education and home ownership. These two cross tabulations are contained in Tables 5.8 and 5.9.

As we might expect, willingness to pay for water pollution abatement is positively related to education. Fifty percent of those interviewed with less than a high-school education estimated their willingness to pay at less than $5;

TABLE 5.8

Cross Tabulation of Education and Willingness to Pay

Willingness to Pay Education	$0-5	6-10	11-25	26-49	50-99	100-199	200+	TOTAL
Less than High School	18	3	6	0	7	1	1	36
High School	31	10	13	3	6	11	7	81
Some College	14	5	9	0	8	5	3	44
Four Years College	6	3	7	1	1	9	1	28
Masters	2	2	0	1	1	0	1	7
Ph.D.	1	0	0	0	2	1	0	4
TOTAL	72	23	35	5	25	27	13	200

TABLE 5.9

Cross Tabulation of Home Ownership and Willingness to Pay

Willingness to Pay Home Ownership	$0-5	6-10	11-25	26-49	50-99	100-100	200+	TOTAL
Owners	58	13	29	3	20	21	10	154
Renters	14	10	6	2	5	6	3	46
TOTAL	72	23	35	5	25	27	13	200

only 23 percent of those individuals with a college education or more indicated this low willingness to pay. The relationship between education and willingness to pay, however, is somewhat less significant than that between income and willingness to pay; the education-willingness to pay relationship is significant at only the .10 level.

I further considered the extent to which home ownership altered people's willingness to pay for improvement of the river. Owning a home in an area would seem to increase an individual's attachment to that area and, thus, increase his willingness to pay for cleaning up a river in that area. Further, homeowners might expect to reap windfall gains in terms of property value increases if the river quality is improved. In fact, the data collected in this survey substantiates this hypothesis; homeowners in general have a higher demand for river quality than do renters. The median willingness to pay for clean-up of the Merrimack is $13.10 for homeowners, and $9.50 for renters. This relationship is significant at the .01 level.

Clearly, income, education, and home ownership are not randomly associated in the sample population. In order to disentangle these variables, as well as to correct for other effects, I ran a regression analysis with these and other variables as independent variables and willingness to pay as the dependent variable.

The estimated equation is below:

1. $$W = .0012522\,Y + 8.8761\,S + .0278\,E + 10.683\,P + .29121\,M - 3.3508\,H$$
$$\quad (.00101) \quad (15.02) \quad (3.129) \quad (4.101) \quad (.2021) \quad (3.011)$$

where Y = income
S = sex, 1 for male, 0 for female
E = education
P = number of people in the family, in the house
M = miles currently travelled to recreate
H = home ownership, 1 for renter, 0 for owner

Standard errors are given in parentheses.

The regression results reported here should be interpreted with considerable care since the analysis was performed on coded variables. Nevertheless, all of the variables in the estimated equation were of the right sign. A calculation of beta weights for the coefficients indicates that the most important determinants of willingness to pay for improved river quality are family size and home ownership. Income and the distance currently travelled for recreation are also important. The income elasticity derived from the regression coefficients above is .70, which is somewhat lower than that estimated from the cross tabulations. The coefficients of sex and education are both insignificant; undoubtedly the high collinearity of education and income is partially responsible for the weakness of the education variable. On the other hand, to the extent that lower incomes reported by the survey population understate true incomes, due to the presence of students and the aged in the sample, regressivity will be underestimated.

The benefit estimates provided by this survey require some adjustment. In particular, in Section 5.1, I discussed the problems imposed by endogeneity of tastes for interpreting ex ante willingness-to-pay figures. I suggested there that, largely because of learning-by-doing effects, residents of areas with relatively good water quality would value water pollution abatement efforts more than residents of areas in which the river has historically been badly polluted. Data collected in this survey provide some support for this hypothesis. In particular, the North Branch of the Nashua River, a tributary of the Merrimack, has been badly polluted for some time. If we compare the median willingness to pay for river clean-up of residents of towns in the historically cleaner north Merrimack region, we find significant differences in respondents' willingness to pay. In particular, the median willingness to pay of residents in towns on the Nashua is \$8.75; for residents on the north section of the Merrimack, median willingness to pay is \$13.75. This higher willingness to pay for water quality improvements by residents of the north Merrimack region is particularly striking when we consider the fact that this area at present requires less water pollution abatement; it is already cleaner than the Nashua.

Thus, the aggregate benefit estimate of \$12.14 per year per basin resident in all likelihood underestimates the "true" benefits of water pollution abatement programs. Moreover, if, as might be supposed, the learning-by-doing phenomenon affects low income people more than high income individuals, the *ex ante* willingness-to-pay estimates described here may well overstate the regressivity of water pollution abatement programs.

5.3.3 Are Preferences for Water Pollution Abatement Reflected in the Political Process?

In Chapter 3 of this study, a number of determinants of intermunicipality variance in water pollution abatement expenditures were identified. To what extent are these intermunicipality expenditure determinants consistent with the individual demand determinants derived in this chapter? In short, to what extent are community preferences accurately reflected in the political process?

Income and proximity to the river were important variables in determining both individual demand for and town expenditures on river quality improvements. In both analyses, income elasticities exceeded one; thus, both on an individual basis and in the town decision, water pollution abatement appears as a luxury good.

Property ownership fared less well. In particular, in the political model, the percentage of town residents who were homeowners was inversely related to the level of expenditures chosen by towns on water pollution abatement. Thus, town decision makers seem to believe that owning a home decreases demand for water pollution abatement; in short, the tax effects dominate. The benefit survey, however, suggests that homeowners have a higher demand for river quality than do renters, despite the fact that they recognize that they will be incurring a higher percentage of the costs of that quality improvement. In short, in this area, the political mechanism does not seem to be accurately reflecting community preferences.

5.4 The Net Incidence of Water Pollution Abatement Efforts on the Merrimack

The willingness-to-pay survey conducted in the Merrimack River Basin strongly suggests that the benefits of water pollution abatement efforts are progressive; that is, benefits increase more than proportionately with income. Moreover, the costs analysis of Chapter 4 suggests that the cost of these programs is regressive; cost burdens increase less than proportionately with income. Thus, it is clear that the net benefits of water pollution abatement programs must also be regressive. Is is possible to quantify this regressivity more precisely?

In Chapter 4, three estimates of the distribution of the local costs of water pollution abatement on the Merrimack were outlined: one assuming full property tax financing and two more hybrid estimates which assumed varying combinations of expenditure substitution and property tax financing. In deriving net incidence, the more conservative of the two hybrid cost distributions was compared with the benefit distribution derived from the willingness-to-pay survey. Table

5.10 below summarizes this comparison and provides an estimate of the incidence of annual net benefits from water quality improvements.

TABLE 5.10

Annual Net Benefits of Water Pollution Abatement
The Merrimack River Basin

Income Level	Net Benefits
Less than $3,000	$ .20
3,000 - 4,999	.03
5,000 - 9,999	3.03
10,000 - 14,999	6.87
15,000 - 19,999	14.50
20,000 +	11.25

The data suggests that all income groups benefit, on net, from water pollution abatement. However, throughout the bulk of the income range, net benefits are sharply progressive. This result suggests that some policy changes in the areas of financing and implementing the new federal water quality directive might well be appropriate.

6. Conclusions

This study focused on two principle issues: first, how are the level and financing of local water pollution abatement expenditures determined? Secondly, what are the effects of these expenditure decisions on the level and distribution of real income? Both questions were addressed by using empirical evidence from the Merrimack River Basin.

Despite fairly stringent federal legislation, the evidence suggests that local governments retain substantial discretion in choosing pollution abatement expenditure levels. Data further indicate that towns exercise this discretion largely in response to community preferences for clean water; thus, slightly more than 35 percent of the intermunicipality variance in water pollution abatement expenditures is explicable by community preference variables. Town median income, proximity to the river, and home ownership are the most significant of these preference surrogates.

Variation in community preferences for river quality improvement, however, is not the whole story. The evidence generated by this study strongly suggests that the levels of political competition in an area have a significant effect on water pollution abatement expenditure levels. In particular, strong political competition seems to have a depressing effect on expenditure levels, as well as on the propensity of towns to finance expenditures through increased taxation rather than through expenditure substitutions, This result is consistent with an organismic model of the state, in which local government decision-makers behave as growth-maximizers, subject to a voting constraint. At a minimum, the evidence generated by this research suggests the need for further work based on the organismic state model.

The net benefits of water pollution abatement expenditures appear to be progressive: that is, benefits increase more than proportionately with income, and costs increase less than proportionately with income. Quantifying the net incidence of the water program requires making a number of rather tenuous assumptions; however, the fact of progressivity of net benefits persists under a wide range of alternative specifications of cost and benefit distributions; only the extent of that progressivity varies.

Current water pollution abatement programs, then, appear to run counter to federal stated objectives of equalizing the income distribution. Yet, when viewed as a package, these programs appear to be efficient: that is, benefits exceed costs. Thus, abandoning water pollution abatement appears to be an inappropriate response.[1] Given the need for some water quality improvements, what program modifications might

---

[1]Abandoning these programs is also, not incidentally, likely to be politically unfeasible.

be most appropriate as a way to remedy maldistributional side effects?

First, the larger the federal share of pollution abatement expenditures, the more progressive will be the costs of these programs. Thus, one solution might be to shift costs to the federal level, where taxation tends to be most progressive. This study suggests, however, that an alternative, less radical solution is available. In particular, cost incidence is quite sensitive to the mode of financing used by <u>local governments</u>. Thus, local governments might themselves remedy the maldistributional impacts of water pollution abatement by shifting away from property taxation and toward a form of either recreational user charges or expenditure substitution.

BIBLIOGRAPHY

Arrow, Kenneth, Social Choice and Individual Values (New Haven: Yale University Press, 1951).

____________, "Political and Economic Evaluation of Social Effects and Externalities", in Margolis, ed., The Analysis of Public Output (New York: National Bureau of Economic Research, Columbia University Press, 1970).

Bahl, Roy and Robert Saunders, "The Determinants of Changes in State and Local Government Expenditures", National Tax Journal, Vol. XVIII, No. 1 (March, 1965).

Bain, Joe, Barriers to New Competition (Cambridge: Harvard University Press, 1956).

Baumol, William, Business Behavior, Value and Growth (New York: Harcourt, 1959).

Bergson, Abram, "A Reformulation of Certain Aspects of Welfare Economics", Quarterly Journal of Economics, Vol. LII, No. 2, (February, 1938).

Bishop, Bruce, Clarkson Oglesby and Gene Willeke, "Community Attitudes towards Freeway Planning", in Highway Research Record, No. 305, (Washington: Highway Research Board, 1970).

Black, Duncan, The Theory of Committees (Cambridge: Cambridge University Press, 1968).

Blackburn, Anthony, "A Non-linear Model of the Demand for Travel", in Richard Quandt, The Demand for Travel (Massachusetts: Heath Lexington Books, 1970).

Bonnen, J. T., "The Absence of Knowledge of Distributional Impacts: An Obstacle to Effective Policy Analysis and Decisions", in Haveman and Margolis, Public Expenditures and Policy Analysis (Chicago: Markham Publishing, 1970).

Buchanan, James, "The Pure Theory of Government Finance: A Suggested Approach", Journal of Political Economy, Vol. LVII, No. 6, (December, 1949).

____________ and William Craig Stubblebine, "Externality", Economica, Vol. XXIX, No. 16 (November, 1962).

____________ and Tullock, The Calculus of Consent (Ann Arbor: University of Michigan Press, 1962).

Clawson, Marion, Methods of Measuring the Demand for and Value of Outdoor Recreation, Reprint No. 10 (Washington, D.C.: Resources for the Future, 1959).

Dales, J. H., Pollution, Property, and Prices (Toronto: University of Toronto Press, 1968).

Davidson, Paul, F. Gerard Adams, and Joseph Seneca, "The Social Value of Water Recreational Facilities Resulting from an Improvement in Water Quality: The Delaware Estuary", in Kneese and Smith, Water Research (Baltimore: Johns Hopkins Press, 1965).

Davis, Otto and George Haines, "A Political Approach to a Theory of Public Expenditures: The Case of Municipalities", National Tax Journal, Vol. XIX, No. 3 (September, 1966).

__________ and Melvin Hinich, "A Mathematical Model of Policy Formation in a Democratic Society", in Joseph Bernd, Mathematical Applications in Political Science, Vol. 2, (Dallas: Arnold Foundation Press, 1966).

Dorfman, Nancy, Who Bears the Cost of Pollution Control? (Washington, D.C.: Council on Environmental Quality, August, 1973).

Dorfman, Robert, ed., Measuring the Benefits of Government Investments (Washington, D.C.: Brookings, 1965).

______________ and Henry Jacoby, "A Model of Public Decisions Illustrated by a Water Pollution Policy Problem", HIER Discussion Paper #91 (Cambridge, Massachusetts, October, 1969).

Downs, Anthony, An Economic Theory of Democracy (New York: Harpers, 1957)

Fabricant, Solomon, The Trend in Government Activity in the U. S. Since 1900 (New York: National Bureau of Economic Research, 1952).

Fenton, John, "Two Party Competition and Governmental Expenditures", Paper presented at the American Political Science Association annual meetings, September 5-8, 1962.

Fisher, Glenn W., "Interstate Variation in State and Local Government Expenditures", National Tax Journal, Vol. XVII, No. 1 (March, 1964).

Freeman, A. Myrick, "Income Distribution and Public Investment", American Economics Review (June, 1967).

_______________, "The Distribution of Environmental Quality", in Kneese and Bower, Environmental Quality Analysis (Baltimore: Johns Hopkins Press, 1972).

Gabler, L. R. and Joel Brest, "Interstate Variation in Per Capita Highway Expenditures", National Tax Journal, Vol. XX, No. 1 (March, 1967).

Gillespie, "Effects of Public Expenditures on the Distribution of Income", in Musgrave, Essays in Fiscal Federation (Washington, D.C.: Brookings, 1965).

Harberger, A., "The Demand for Nonfarm Housing", in Harberger, The Demand for Durable Goods (Chicago, 1960).

Haveman, Robert, Water Resource Investment and the Public Interest (Tennessee, 1965).

Herriott and Miller, "The Taxes We Pay", Conference Board Record (May, 1971).

_______________, "Tax Changes Among Income Groups, 1962-1968", Business Horizons (February, 1972).

Hotelling, H., in Roy A. Prewitt, The Economics of Public Recreation, U. S. Department of the Interior, National Park Service, 1949.

Jackson, John, "Politics and the Budgetary Process", Social Science Research, Vol. 1, No. 1 (April, 1972).

Knetsch, Jack, "Outdoor Recreation Demands and Benefits", in Land Economics, Vol. 39, No. 4 (1963).

_______________ and Robert Davis, "Comparison of Methods for Recreation Evaluation", in Kneese and Smith, Water Research (Baltimore: Johns Hopkins Press, 1965).

Kurnow, Ernest, "Determinants of State and Local Expenditures Reexamined", National Tax Journal, Vol. XVI, No. 3 (September, 1963).

Ladd, Helen, "The Role of the Property Tax", unpublished paper, Harvard, 1973.

Mack, Ruth and Sumner Meyers, "Outdoor Recreation", in Robert Dorfman, ed., Measuring the Benefits of Government Investment (Washington, D.C.: Brookings, 1965).

Margolis, Julian, ed., The Analysis of Public Output (New York: National Bureau of Economic Research, Columbia University Press, 1970).

Marris, Robin, "A Model of the Managerial Enterprise", Quarterly Journal of Economics, Vol. LXXVII, No. 2 (May, 1963).

Merewitz, Leonard, "Recreational Benefits of Water Resources Development", Water Resources Research, Vol. 2, No. 4 (Fourth Quarter, 1966).

Meyer, John and Mahlon Straszheim, Pricing and Project Evaluation, Vol. 1 (Washington, D.C.: Brookings, 1971).

Mishan, E. J., "Reflections on Recent Developments on the Concept of External Effects", Canadian Journal, Vol. XXXI, No. 1 (February, 1965).

Musgrave, Richard, "The Distribution of Tax Payments by Income Group", National Tax Journal (March, 1951).

______________, The Theory of Public Finance (New York: McGraw Hill Book Company, Inc., 1959).

______________ and Peggy Musgrave, Public Finance in Theory and Practice (New York: McGraw Hill Book Company, Inc., 1973).

Netzer, Richard, Economics of the Property Tax (Washington, D.C.: Brookings, 1966).

Niskanen, William, Bureaucracy and Representative Government (New York: Atherton, 1971).

Roberts, Marc, et. al., Metropolitan Water Management, a study done for the National Water Commission by Urban Systems Research and Engineering, Inc., January, 1971).

Sacks, Seymour and Robert Harris, "The Determinants of State and Local Government Expenditures and Intergovernmental Flows of Funds", National Tax Journal, Vol. XVII, No. 1, (March, 1964).

Samuelson, Paul, Foundations of Economic Analysis (Cambridge: Harvard University Press, 1947).

Samuelson, Paul, "The Pure Theory of Public Expenditures", Review of Economics and Statistics, Vol. XXXVI, No. 4, (November, 1954).

Sen, A. K., "Planners' Preferences: Optimality, Distribution, and Social Welfare", in Julian Margolis and H. Guitton, eds., Public Economics (New York: St. Martin's Press, 1969).

Sharkansky, "Some More Thoughts about the Determinants of Government Expenditures", National Tax Journal, Vol. XX, No. 2 (June, 1967).

Spangler, Richard, "Effect of Population Growth upon State and Local Government Expenditures", National Tax Journal, Vol. XVI, No. 2 (June, 1963).

Tax Foundation, Tax Burdens and Benefits of Government Expenditures by Income Class (New York, 1967).

U.S. Treasury Department, Statistics of Income, Individual Income Tax Returns, 1960.

Weicher, John, "Aid, Expenditures, and Local Government Structures", National Tax Journal, Vol. XXV, No. 4 (December, 1972).

Williamson, Oliver, "Managerial Discretion and Business Behavior", American Economics Review, Vol. LIII, No. 5, (December, 1963).